SEED PRODUCTION TECHNOLOGY

REPORT OF THE
INTERNATIONAL POTATO CENTER'S
PLANNING CONFERENCE ON SEED
PRODUCTION TECHNOLOGY

INTERNATIONAL POTATO CENTRE INTERNACIONAL DE LA PAPA

LIMA PERU

INTERNATIONAL POTATO CENTER

REPORT OF THE

PLANNING CONFERENCE

ON

SEED PRODUCTION TECHNOLOGY

Held at CIP - Lima, Peru

October 21-25, 1974

INTERNATIONAL PLANNING CONFERENCE

ON

SEED PRODUCTION TECHNOLOGY

FOR

DEVELOPING COUNTRIES

At the request of Dr. Richard L. Sawyer, Director General of the International Potato Center, a Planning Conference was held to establish priorities and recommend specific programmes for the establishment of a sound seed production program suited to the needs of developing countries.

The International scope of the Conference is apparent in the following list of invited participants recognized as seed production experts in seven countries.

PARTICIPANTS

E. Ohms (Co-Chairman)	Cooperative Extension Services University of Idaho 634 Addison Ave. West Twin Falls, Idaho 83301 U.S.A.
J. Christiansen	Coordinador del Programa Nacional de Papa Ministerio de Agricultura Av. Salaverry s/n Lima PERU
P. Eastman	Deputy Commissioner Department of Agriculture Division of Plant Industry Ministry of Agriculture Augusta, Maine 94330 U.S.A.
S.A. El-Baz	Director, Potato Section Vegetable Research Department Ministry of Agriculture Dokki - Cairo EGYPT
E.R. Keller	Institut fur Pflanzenkan ETH Eidg. Technische Hoschschule Zurich Universitatstrasse 2 CH - 800 Zurich SWITZERLAND

L.C. Sikka	Project Coordinator Central Potato Research Institute Simla - 1 (H.P.) INDIA
D.E. Van der Zaag	Research Station for Arable Farming P.O. Box 33 Wageningen NETHERLANDS
N.S. Wright	Head, Plant Pathology Section CDA Research Station 6660 N.W. Marine Drive Vancouver 8, B.C. CANADA

The following CIP personnel also participated in the Plannning Conference:

P. Accatino	CIP Regional Program Leader Mid East
J. Bryan	Seed Production Specialist, CIP, Lima
O. Hidalgo	CIP Regional Program Leader, South America
A. Hinostroza	Virologist, CIP, Lima
R. Jones	Virologist, CIP, Lima
O. Page	Director of Research (Co-Chairman)
W. Roca	Plant Physiologist, CIP, Lima
R. Sawyer	Director General of CIP, Lima

K. Sayre	Head, Dept. of Plant Physiology, CIP, Lima
M. Twomey	Economist, CIP, Lima
M. Villarreal	CIP Regional Program Leader, Central America
R. Wurster	Head, Outreach and Training Program, CIP, Lima

Front Row: Drs. Bryan, Twomey, Accatino, El-Baz, Page

Rear Row: Drs. Ohms, Hidalgo, Villarreal, Wurster, Eastman, Wright, Van der Zaag, Keller and Sikka

CONTENTS

I. SEED POTATO RECOMMENDATION FOR DEVELOPING COUNTRIES

1. Evaluate varieties for all conditions within the country.

   a. Planting and harvesting dates in different seasons of production.

   b. Post harvest and storage capabilities.

   c. Market preferences.

2. Identify the limiting factors in potato production which can be influenced by quality of seed.

   a. Diseases.

   b. Insects and nematodes.

   c. Varietal purity.

   d. Physiological factors.

   e. Seed size.

3. Locate most suitable areas in the country for seed production.

   a. Climatic conditions.

   b. Grower capability.

   c. Insect population dynamics.

   d. Presence of soil pathogens and pests.

   e. Isolation possibilities.

   f. Rotation possibilities.

   g. Storage and transportation capabilities.

Trial plots in candidate areas to carefully monitor the infection pressure and degeneration of seed quality is recommended as an evaluation procedure. These plots should contain known levels of the pertinent virus diseases in the adapted varieties of the country. The seed produced on these plots should be planted in a central location representative of commercial producing areas and evaluated for disease content and productivity.

More sophisticated trials which include different planting dates, killing of haulms, storage studies, and manipulation of factors affecting physiological age are recommended.

4. Determine realistic goals as to disease content which may be attainable and still result in improved production. These goals will vary depending upon the situation and visible virus disease. Disease range might be allowable which even exceed considerably the 10% level assumed not to decrease yield in commercial fields.

Tolerance for other diseases and pests should be considered in the same light.

The above applies to seed intended for planting potatoes for consumption. It may be the progeny of imported seed or seed produced by a program within a country.

5. Feasibility and location of a national seed production program having been determined, the appropriate local authorities should be encouraged to establish a plan for production, storage and distribution with the guidance of CIP personnel, taking into consideration the following factors:

A. Production.

1. Isolation

Ideally, seed should be produced in areas limited to seed production. When this is not possible seed fields should be separated by a minimum of 25 meters from non-seed fields.

2. Cultural practices

a. Appropriate crop rotation.
b. Pre-sprouting and consideration of physiological age to manipulate size of tubers of progeny.

c. Seed size and plant density.
d. Consider carefully the dangers involved before planting cut seed.
e. Use adequate fertilization but avoid excess Nitrogen application.

3. <u>Timely pest and disease control</u>

a. Roguing.
b. Pesticide applications.
c. Haulm destruction.
d. Sanitation practices, e.g. equipment, containers, etc.

B. Storage and handling.

1. Minimize harvest and transport injury.

2. Allow period of curing before final storage (1-2 weeks).

3. Sort out damage and defects and segregate sizes before final storage.

4. Store under most advantageous conditions for the planting date and other local factors.

5. Control tuber diseases and pests.

C. Distribution.

1. Devise a system to maintain identity of seed lots by size and tuber quality.

2. Depending upon local marketing customs, do everything possible to assure that seed reaches the growers who should plant it.

6. Seed growers through appropriate organization should collaborate in planning the inspection procedures and engaging in practical research.

7. The success of any seed program in a developing country will depend heavily upon the availability of trained people for advisers, inspectors, research people and all involved. We strongly recommend that CIP personnel encourage and participate in training activities if other competent sources of training are not available, then are to be provided for:

A. Extension Workers.

Short course training in the country on seed potato production.

B. Inspectors.

Courses in the country on diseases in growing plants and seed tuber quality including roguing and sorting tubers.

C. Supervisors and Leaders.

Special courses on seed potato production and storage usually outside country (2-5 months).

D. Research Workers.

Same as 3 above with emphasis upon applied research.

8. Success in one-generation multiplication may lead to 2- and 3-generation systems and then to more sophisticated systems, but advance to longer multiplication plans should depend upon success in shorter ones.

If a 2- or 3- generation multiplication is found to be successful then studies should be initiated to determine the feasibility of a basic seed program including clonal selection, and then many other possible components. Cost analysis of each step should be maintained in comparison to the cost of imported seed.

Developing countries should be encouraged to utilize the existing capabilities for disease elimination by meristem cultures, available at CIP.

II. RECOMMENDATIONS FOR CIP IN ORDER OF PRIORITY

1. The increasing demand for training activities in developing countries cannot be fulfilled by current CIP Outreach and Core personnel, and it is suggested that training staff be increased accordingly.

2. Since in developing countries seed potatoes are being produced in tropical and sub-tropical regions, it should be determined how to properly manipulate temperatures, air flow, humidity, light, dormancy breaking and sprout suppresion to obtain seed in correct conditions for local planting.

3. Develop economic models so that cost analysis and evaluation can be made of the different seed programs.

4. Investigations on the stem cutting, meristem and callus culture methods should be continued so as to aid in pathogen eradication, maintenance and distribution of selected germplasm.

5. Tolerance to heat and/or frost injuries, and resistance to cyst nematodes, leaf roll virus, brown rot, wart, late blight and PVY, should continue to be incorporated into germplasm so as to have these available for breeding programs throughout the world.

6. Because it has been well documented that potato plants develop "resistance" to PVY and leaf roll viruses as the plant ages, it is reasonable that this phenomenon should be understood and made an area for research.

7. Trials should be established to determine the practicality of homogenous botanical seed for economic production.

Centro Internacional de la Papa

PLANNING CONFERENCE ON SEED PRODUCTION TECHNOLOGY FOR DEVELOPING COUNTRIES

AGENDA

Monday, October 21

9:00	Introduction of Participants and Overview of the Objectives of the Planning Conference. Dr. R.L. Sawyer, Director General
9:30	Tour of CIP facilities
10:15	Coffee
10:30	Position Paper - "Strategy of Seed Production Technology in Developing Countries". Dr. R.E. Ohms
12:00	Lunch at La Molina

Monday afternoon

1:30 I Present Seed Production Technology in the United States and Canada
Dr. P. Eastman

A. Definition of seed types:

Basic or Elite; Foundation; Certified

B. Production Sequence and Distribution of Seed:

1. Selection of initial material
2. Site selection and planting methods
3. Cultural practices
4. Sanitation, inspection and quarantine
5. Harvesting and storage
6. Economics of seed production
7. Grower organizations
8. New approaches being introduced

2:15 Discussion of North American Seed Production Technology.

2:45 Coffee

3:00 II <u>Present Seed Production Technology in Europe</u>
Dr. E. Keller
(As per topic sequence, Part I, A and B)

3:45-4:30 Discussion of European Seed Production Technology; Comparison of Merits of European and North American Technologies.

<u>Tuesday Morning, Cotober 22</u>

III <u>Limitations of Seed Production Technology Introduced from Developed Countries into Developing Countries.</u>

9:00 A. World regions where CIP is interested in seed production.
Dr. R. Wurster

9:15 B. Present sources of seed in developing countries.
Mr. J. Bryan

C. Some limitations to seed production in developing countries.
Moderators: [illegible]. Ohms and O.T. Page

9:30		1.	Import restrictions
		2.	Costs - foreign exchange
		3.	Trained people and facilities
10:05	Coffee		
10:20		4.	Formal institutions responsible for seed program
10:30		5.	Agrarian reforms
10:40		6.	Distribution systems - transportation
10:50		7.	Saturation of demand for seed
11:00		8.	Storage
11:15		9.	Number of growing seasons per year
11:30		10.	Grower risks
11:45		11.	Marketing channels

Tuesday afternoon

IV. Biological and Physical Limitations of Northern Latitude Seed Technology for Developing Countries

1:30	1.	Genetic background of seed - photoperiodic and other physiological responses. Dr. D. Van der Zaag
1:50	2.	Insects and diseases as limiting factors. Dr. N. Wright
2:10	3.	Planning seed production to fit climatic zones; breeding to overcome dormancy and influence of extremes in altitude and range of latitude. Dr. L. Sikka

2:35	4.	Present problems with imported seed. Dr. Said el Baz
3:00	Coffee	
3:15	5.	Problems of seed multiplication and distribution in the Andean region. Dr. J. Christiansen
3:15-4:15	6.	Acceptable disease tolerance. Moderators: Drs. R. Ohms and O.T. Page

<u>Wednesday Morning, October 23</u>

V <u>Innovative Research in Seed Production Applicable to Developed Countries</u>

9:00	1.	Apical meristem techniques. Dr. N. Wright
9:20	2.	Comment on apical meristem research at CIP. Dr. W. Roca
9:30	3.	Callus and free cell culture techniques at CIP. Dr. W. Roca
9:50	4.	Comments on "disease-free" terminology. Dr. O. T. Page
10:00	Coffee	
10:15	5.	Discussion: "The spindle tuber problem". Moderators: Drs: R. Ohms and O.T.Page
10:30	6.	Breeding for virus resistance. Dr. R. Rowe
11:00	7.	Discussion: "The potential for use of true (botanical) seed". Moderator: Dr. O.T. Page

11:30 8. Other new research approaches to improve seed production.
Moderators: Drs. R. Ohms and O.T. Page

12:00 Lunch at La Molina

Wednesday afternoon

VI Adaptation of new research "break throughs" to seed production in developing countries.

1:30-4:00 General discussion moderated by Drs. R. Ohms and O.T. Page

1. Applicability of meristem and tissue culture techniques.
2. Incorporation of virus, metavirus (viroid) and bacterial resistance in breeding programs.
3. Other considerations.

Coffee will be served during the discussion period.

Thursday, October 24

9:00-4:00 Committee to Summarize Discussion and to prepare an Agenda for Final Recommendations and Priorities.

Dr. R. Ohms
Dr. P. Eastman
Dr. D.E. Van der Zaag
Dr. O.T. Page

9:00 Other Participants
Discussions with CIP staff

12:00 Lunch at La Molina

Thursday afternoon

1:30	Other Participants Tour of field plots and points of interest at La Molina.

Friday morning, October 25

9:00	Discussion of Final Recommendations and Assignment of Research Priorities. Moderators: Drs. R. Ohms and O.T. Page
12:00	Lunch at La Molina

Friday afternoon

1:30	Continued Discussion of Recommendations.

INTRODUCTION

The basic objectives of the International Potato Center are to:

increase the yielding capability and efficiency of production in the developing countries where the potato is being grown, and extend the geographical range of the potato, including the lowland tropics.

One of the principal keys to fulfilling these objectives in developing countries is to build strong national seed production programs each tailored to the special conditions of an individual country.

In the building of a seed production program the existing technical agricultural personnel of a country must be first motivated by a desire to improve potato production. Initially, substantial yield increases may be achieved in most cases by the importation and testing of well-known varieties from developed countries. Encouraged by such yield increases a sound seed production program may evolve. It is the aim of the Planning Conference on Seed Production Technology to give guidance to production methods widely adaptable to the varying socio-economic. agro-ecological and agro-technical conditions of a country.

The recognition in a country of the need for a seed production program may be stimulated by a number of factors such as:

1. The possibility of improving production.
2. Economic - the cost of seed; foreign exchange considerations.
3. Availability and timing of supply.
4. Phytosanitary regulations restricting ready import of seed.
5. The desire to improve the stature of potato growing as an industry.
6. Providing seed for the flexible expansion of state programs

Conference participants have been cognizant of these and other factors in wide-ranging discussions on the limitations of seed availability in many developing countries. Such factors merely emphasize the importance for the early implementation of sound seed production programs wherever such programs are feasible.

To assist in developing guidelines for Outreach personnel a number of papers on specific topics were presented. They compose the body of this Planning Conference Report. The thoughts expressed in these papers, together with pertinent observations elucidated by discussion have been integrated and focused to provide the Recommendations set forth in this Report.

POSITION PAPER

ON

THE STRATEGY OF SEED POTATO PRODUCTION IN DEVELOPING COUNTRIES

R. E. Ohms

A position paper can be defined as a statement which presents the problem and outlines the discussion topics or subjects which are needed to develop the desired strategy. The purpose of this conference is to develop the guidelines (blue print) for evaluating the need and procedure by which to develop seed potato programs in developing countries. No attempt has been made to present a complete literature review of papers that deal with the topic of seed potato production. Sufficient references and data have been used which represent, define, or illustrate seed potato production and programs.

I. Introduction

To set the stage and get your thinking away from home let us look at the world as if it were a village - a village with a population of 1,000. In this village there would be 60 North and 80 South Americans; 210 Europeans; 85 Africans; and 565 Asians. There would be 300 white people and 700 non-white. Three hundred of the 1,000 would be Christian, 150 would be Moslem, 125 Hindu, 100 Confucian, and 85 Buddhist. Half of the total income of the village would be in the hands of 60 people. Almost all of the affluent part of the village would be composed of Christians from Europe and North America. Over 700 of the 1,000 villagers would be unable to read. Over 500 would be suffering from malnutrition. Over 800 would live in what we call substandard housing. No more than 10 would have a university education. /1.

/1 Stephen F. Bayne, Jr., International Development Research Center, Ottawa, Canada.

That is the clientele situation in a world village. Project your "potato" thinking to the developing world. Some of the things you would find are good climates, good soils, and good demand. Unlike temperate zones the supply of labor is good. In developed countries, labor saving methods are necessary whereas in developing countries labor using practices can be followed. As we develop the strategy of seed production be sure to keep this point in mind.

II. Seed Productivity

The production of high quality potato seed is dependent upon the influence of physiological factors as well as disease-causing organisms on the productivity potential of the seed. Certified seed procedures and seed increase programs have been traditionally designed to improve and maintain variety purity, disease control and identification of potatoes through the channels of trade. Physiological factors which affect the productivity of seed are often overlooked in seed increase programs because seed production may flourish with minimum attention to such factors in climates or areas which are naturally adapted to potato production. In tropics or non-temperate zones physiologic factors become more acute.

Physiological Aging. - The effect of physiological aging has been studied by Perennec and Madec (1960) and Kawakami (1963). Hutchinson (1974) recently reviewed the literature and summarized effects of physiological aging as follows: The physiological age of the seed tuber affects the rate of sprout growth and the structure and number of sprouts formed. As the physiological age of the tuber increases, the number of eyes that sprout increases and the rate of sprout growth first rises, then declines. There is an increasing tendency for branch formation and swelling at the base of the sprout. Field growth is also affected by the physiological age of the seed. Plants grown from physiologically older seed emerge earlier, have a higher initial growth rate and a shorter time from emergence to tuber initiation than physiologically younger seed. However, haulm growth is retarded and finally stopped by tuber production and so plants from physiologically older seed have smaller haulms which senesce earlier than that from physiologically younger seed.

Physiologically older seed out yields younger seed during the first part of the growing season. However, if physiologically young seed is allowed to grow to maturity a large haulm

is produced, senescence is slow and subsequently a longer period is required for tuber sizing. Higher yields are produced in long growing seasons from young seed and in short growing seasons from old seed. Van der Zaag (1973) suggests that physiologically old seed should be planted for seed production while for ware production physiologically young seed should be planted. The development of the crop from old seed would be faster and thus could escape late season spread of virus.

Many workers have related factors affecting the physiological age of the seed. These might be grouped as 1. Chronological Age. 2. Temperature during production. 3. Maturity at Harvest, and 4. Storage Temperature. It should be pointed out that all these factors probably interact together and thus, they become important in manipulating the correct age of the seed for the purpose intended. To do more than just mention them would direct us away from the assignment we have in developing seed potato strategy. However, they are important and you should be aware of them.

Chronological Age - Chronological Age has been defined as the length of time from planting the seed crop to planting the following crop Kawakami (1963). Perhaps more important than planting or emergence dates is the length of time between tuberization of the seed crop and subsequent tuberization of the ware potato crop.

Temperature During Production - The Environmental conditions are most often manifested by difference in performance of two lots of seed produced in different locations. Temperature during production is usually considered to be the most important environmental factor. Went (1959) related day length and temperature to productivity. According to Bodlaender (1973), the warmer temperatures during seed tuber production results in physiological older seed tubers. Seed tubers produced at 16°and 22°C had superior yield to those produced at 28°C.

Maturity at Harvest - This factor is often confounded by chronological age. Maas (1971) studying different planting and harvest date combinations found that for the Russet Burbank variety the most mature seed stock (from an early planted-late harvest crop) produced lower yields than less mature seed stocks.

Storage Temperatures - The effect of storage temperatures on productivity of seed has been reported by many workers (Iritani 1968; Murphy et al 1968). However, the interaction effects of the

previously mentioned factors are quite important. Fischnich and Krug (1963) related storage temperatures to variety, time of harvest and weather conditions. In order to get an early tuber yield, the seed should be stored at a relatively high temperature (8°-15°C) and illuminated to restrict sprout elongation and losses of dry matter. A similar effect can be achieved by pre-sprouting, a procedure which is successfully used in farming. The highest final tuber yield is produced by storage of tubers at low temperatures (about 4°C) if a long growth period is provided. But since the time of emergence of such plants is delayed and the growth period is restricted during the autumn by low temperatures, short days or diseases, they will seldom develop their full yielding potential in Middle Europe. Perhaps one of the most important conclusions was reached by Goodwin and others (1969) that seed of a required state at planting can be obtained by appropriate modifications of the post-harvest environment. Storage factors can produce equal or greater responses than other factors affecting the physiological age of seed.

Mid-East Situation - Although the Mid East is not typical of potato seed production in all developing nations, it can serve as an introduction and is one with which I am somewhat familiar. Many developing countries, including those in the Mid East, now have potato seed programs. In Table 1, you can see that the availability of seed at the correct time in the amount necessary becomes quite important.

Table (1) Seed requirements in metric tons for Iraq, Syria, Egypt, and Jordan according to planting season**

		PLANTING DATE		
Country	Variety	Dec. - Feb.	Apr. - May	July - Oct.
Egypt	(Mixed)*	29,400	-	75,000
Iraq	Bintje	2,600	-	2,600
	ARI	400	-	400
Jordan	Alpha	2,130	50	3,194
Syria	A Banner	5,440	3,240	4,000
	Other	1,200	-	-

* Alpha, Arron Banner, King Edward, & Grata

** Data provided by A. Hason, Iraq; D. Sabbagh, Syria; S. El Baz, Egypt and Z. Nassar, Jordan.

From Table 1, the need for seed of the correct physiological age when planting dates are in July to October. Imported seed would be one-year-old and have to be kept over summer. Local seed would be only 2-3 months old and physiologically young. Dormancy is an additional problem. Do the developing countries need varieties that have long dormant periods?

Seed performance varies with country of production. Some varieties have the reputation of performing best when seed is produced in certain countries. An example is from Lebanon's 1973 variety trials for Arron Banner.

Table 2. Comparison of Arron Banner Seed performance according to location of seed production*

Country	Maturity	Veg.Length	% Tubers by Size 65	45-65	45	Tons/ Hectare
A	Aug. 1	142	77.0	20.0	3.0	64.4
B	July 27	135	52.0	44.0	4.0	61.9

* Lebanon 1973 variety trials.

An example of the effect of physiological age on seed productivity was reported by Sawyer and Cetes (1962) for different sources of Katahdin seed. The location of seed production and its effect on productivity of different varieties was studied in Jordan in 1973. The data, presented in Table (3), reveals a location effect. Some varieties (e.g. Bintje) in the example performed better in the increase program than other varieties (e.g. Patrones).

Table 3. Effect of seed source and variety Tons/Hectare when planted in East Bank - January 1971 /1

	Location where seed produced /2		
Variety	A	B	C
Bintje	25.6	25.7	28.4
Patrones	30.1	28.3	20.9

Another example of physiological aging is in the Nawala vs. cold storage situation in Egypt. This data (Table 4) illustrates the aging that takes place in the warm Nawala Storage and the effects on plant type and yield.

Table 4. Effect of type of storage (Nawala and Cold Storage) on productivity of seed as related to % stand, No. Tubers, Plant Height and Total Yield. /1

Type Storage	% Stand	No. Stems/Hill	Plant Height	Total Yield /2
Cold 1970	84.6	2.9	44.7	11.7
1972	85.6	2.4	38.3	4.1
Average	85.1	2.6	41.5	7.9
Nawala 1970	80.7	3.7	41.9	9.6
1972	80.1	3.8	29.3	3.7
Average	80.4	3.8	35.6	6.6

/1 Data provided by Dr. Nizar Shasha, Dept. of Agric. Research and Extension, Amman, Jordan

/2 A. Imported for 1973 planting
B. Shawbak - one year from import - April 15 planting Aug. 1 harvest
C. Amman - one year from Shawbak - April planting July 15 harvest

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/1 Masters Thesis - Ahmed El Gamal, Hort. Res. Dept., Sabhia-Bakans Alexandria Egypt

/2 Tons per Ferdan

The cost of seed comprises a large proportion of the total cost of production. Figures are difficult to obtain but it is estimated that seed costs are 40 to 60 percent of the total production costs. Often one hears of the offset of production practices in relation to the increase per unit of seed. Increase per unit of seed may vary with factors such as planting rate and variety. If the increase is significant the practice may be adopted. The increase from a unit of seed becomes a dominant factor in establishing production practices, variety to be planted and price. The total yield per hectare is often of secondary importance. Good local seed, if available at the correct time, could be considered an economic tool to higher yields per hectare and more food for people.

III. Seed Increase Programs

The systems for disease control and maintaining seed stock maintenance have been described by Jacobsen (1972) as "negative selection" and "positive selection". Negative selection involves removing recognizable diseased plants (roguing during summer) and eliminating bad lots (winter indexing) prior to planting in seed areas. Positive selection is based on the concept of selecting a pathogen free plant, increasing it thru a generation system until its progeny reaches the commercial (ware potato) producer.

Negative Selection - With the negative selection system a certain level of disease is tolerated. This approach has been used in a practical sense to control potato leaf roll virus, potato virus A, potato virus Y and other diseases which produce visible symptoms on the potato either during the summer or during the winter test.

This system fails when latent pathogens or mild strains of leaf roll, and PVY are encountered. Diseased plants cannot be rogued or diseased stocks eliminated prior to planting in a seed area. Leaf roll strains often affect symptom expression in potatoes, influencing the effectiveness of the negative selection system. These relations have been reported for leaf roll by Webb (1952), Wright (1967) and Ohms (1972). Varietal reaction could also affect the diagnosis of disease, allowing symptomless carriers to serve as reservoirs of infection. Considerable success has been obtained in certain programs where the climate in the winter test allows detection and elimination of PVA-and PVY- infected seedstocks that were

symptomless during the seed production season (Gunthrie, 1960).

Positive Selection - The positive selection is based on the concept of selecting a disease free plant, increasing it thru a clonal selection procedure (generation system). This system of clonal selection progresses at a 10-fold increase each year and requires five to six years before the seed can be distributed to the producer of ware potatoes. The system must have a reselection of healthy plants each year and recontamination can occur during increase generations. It can be reasoned, because of the "flush out" effect, that the longer the positive selection system is followed the easier it is to deliver disease free seed to ware producers.

The advantage of the system is that the procedure can control pathogens that produce mild or latent symptoms. The positive selection system is not generally effective against pathogens that are insect transmitted or soil borne. Hardie (1970) prepared the following, Table 5, which summarizes the characteristics of certain diseases, pathogen, method of spread, visibility of symptoms and whether controlled by clonal selection.

Certain procedures and steps are being incorporated into the positive selection programs. These are meristem culture and stem cuttings to free the plants of pathogens (Norris 1954), (Kassanis 1957), (Kassanis and Verma 1967), (Quak 1972), (Stace-Smith and Mellor 1968), and (Graham and Hardie 1971). The incorporation of stem cuttings into seed increased programs was outlined in the VTSC programs in Scotland (Hardie 1970) and Northern Ireland (Calvert 1972). The application of the stem cutting procedure for rapid build up of basic seed stocks was demonstrated by Cole and Wright (1967) where eight plants derived from a single tuber in December would yield 5,000 rooted cuttings by early May. Thus, the limitations of greenhouse space could be the only limiting factor on the number of generations in the clonal selection program, shortening the number of years for the generation system to flush out pathogens. Plants derived from meristems have reportedly yielded as high as 60 percent greater than regular plants (Gregorini and Lorenzi 1974).

A very recent adaptation of meristem culture and stem cutting has been demonstrated by Dr. Piere Sylvestre /1 in successfully

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/1 Research is presently being published and permission was obtained from Dr. Sylvestre to use the information in this conference.

Table (5) Relation of type of disease and whether clonal selection procedure is effective. (Hardie 1970)

DISEASE	CAUSAL ORGANISM	METHOD OF SPREAD	VISIBILITY OF SYMPTOMS	CONTROLLED BY CLONAL SELECTION
Mild Mosaic	Potato virus X	Contact	Latent or mild	Yes
Latent virus infection	Potato paracrinkle virus and potato virus S	Aphids or Contact	Latent	Yes
Severe Mosaic	Potato virus Y	Aphids	Usually pronounced	No
Leaf Roll	Potato leaf roll virus	Aphids	Usually pronounced	No
Veinal Necrosis	Tobacco veinal necrosis virus	Aphids	Latent or mild	No
Mop-top and Spraing	Potato mop-top virus	Soil-borne	Latent, mild or pronounced	No
Stem Mottle and Spraing	Tobacco rattle virus	Soil-borne	Latent, mild or pronounced	No
Blackleg	Erwinia carotovora var atroseptica	From seed tuber	Latent or pronounced	Yes
Black Scurf	Corticium solani	Soil-borne	Usually pronounced	No
Blight	Phytophthora infestans	Air-and-water-borne	Usually pronounced	No
Common Scab	Streptomyces scabies	Soil-borne	Usually pronounced	No
Dry Rot	Fusarium caeruleum and other species	Soil-borne	Latent or pronounced	No
Gangrene	Phoma exigua var foveata	Mainly from seed tuber	Latent or pronounced	Partly
Powder Scab	Spongospora subterranea	Soil-borne	Usually pronounced	No
Silver Scurf	Helminthosporium atrovirens	Probably from seed tuber	Latent or pronounced	Partly
Skin Spot	Oospora pustulans	From seed tuber	Latent or pronounced	Yes

making transfers from tube to tube of plantlets derived from meristems. Increasing potato plantlets in culture tubes adds new dimensions to maintaining basic seed materials of varieties and clonal lines. Keeping basic materials in culture tubes might also be advantageous in transporting of basic potato stocks over long distances.

IV. Control Programs

Regardless of the type of increase being followed, pathogen control programs have become an integral part of potato seed production. The incorporation of control programs to increase systems often results in excellent seed production in areas where seed production is difficult. Technology can replace natural advantages.

Quarantine and Control Areas - The exclusion of pathogens from an area is one of the oldest procedures used in pathogen control. The method is widely used in Europe for the Golden Nematode where infested fields are no longer eligible for the production of seed potatoes (McKelvie 1968).

An approach to nematode control was proposed by Hijink (1972) which employs resistant varieties and soil disinfection by fumigation. The program is aimed at the prevention or elimination of non-detectable populations of the potato root eelworm.

In British Columbia, the planting stocks allowed into a basic seed area are controlled by an enabling legislation act /1. The act sets up the procedure and authority by which the varieties to be planted are regulated, provides for the inspection, testing and approval of seed potatoes, requires owners and occupiers of lands within the area to rogue defective plants, regulates time at which roguing is to be accomplished and other regulations as may be expedient or necessary to carry out the purposes and provisions of the Act. Home Gardens (Bishop 1964) have been found to be sources of PLRV in seed programs; thus, the regulation of all planting material becomes important to seed production.

/1 Certified Seed-Potato Act R.S. 1948, C257, sl.
British Columbia, Canada.

Aphid Management and Seed Production - In Holland the management of vectors and viruses through trapping programs and vine killing is a classic example of virus control. The procedure is so well worked out that the class of seed is related to the aphid population so that the earlier the vines are killed the higher the class of seed. Each year depending on aphid flights and stage of potato growth dates are fixed for vine killing. Temperatures under 5° C and over 30° C lowers aphid population (Hill Ris Lambers 1972). This information can be useful in timing the seed crop planting as to avoid high aphid populations. For example in northern seed areas aphid populations would be lowest in the spring increasing during summer and fall. In the tropics on the other hand, the lowest populations would follow the high summer temperatures.

Lifting dates at harvest not only affects leaf roll but also decreases the presence of blackleg. In Holland (Maas Geesteranus 1971) the earlier harvest dates results in less blackleg. Also, heavier soil texture and high soil moistures during seed harvest increase the blackleg percentage in the resulting crop. A long interval between vine kill and harvest lowers the blackleg; however, the longer interval increases Rhizoctonia.

Chemical Disinfection of Equipment and Tubers - Sanitation and the ability to decontaminate equipment and storages may well determine the success of a seed program. The blackleg bacteria has been found to survive one year on a potato grader (Graham 1967). However, the bacteria lost its vitality after five weeks at a - 5°C and after 22 weeks at 5° C and fluctuating temperatures between 0 and 20° C (Logan 1968). Chemicals are widely used but are non-effective unless plant residue and dirt are first removed. Recommended chemicals are Quaternary Ammonia 10% solutions at 1/10, Lysol 50% in soap at 1/10; Formaldehyde 40% solution at 1/25 and copper sulfate at one pound to five gal. water (Fenwick 1966).

The treatment of potato tubers for gangrene (Phoma), skin spot, and silver scurf is of special concern. Spraying thiabendazole by mist application (Logan 1973) and fumigation with 2 - aminobutane (Graham 1973) have been found effective against gangrene, skin spot and silver scurf. Fumigation did not control tuber blight (Phytophthora) or dry rot (Fusarium) and did not kill the sclerotia of Rhizoctonia (Graham 1973). Two-aminobutane was less effective against silver scurf.

Thermotherapy - Temperature has been used to eliminate PLRV from infected stocks. Fernow (1964) found that PLRV was completely eliminated from tubers of several varieties by heat treatments at 35° C for 56 days and at 36° C for 39 days. The practical application of this was reported by Thirumalacher (1954). PLRV was eradicated from tubers in the warm storages of India. Further application of heat was used when it was combined with the meristem culture technique to eradicate PVX and PVS. (Stace-Smith and Frances Mellor 1968).

Stem Cutting - The stem cutting procedure was incorporated into the seed increase program in Scotland for the control of the blackleg bacteria (Hardie 1970). The propagation of potatoes by means of above-ground plant parts eliminates the soil borne or pathogens which may be on or in the tubers. The stem cutting procedure was found useful for removal of gangrene and skin spot as well as blackleg from a seed stock in Ireland (Calvert 1972). Corynebacterium sepedonicum was not recovered from cuttings made from potato plants exhibiting wilt symptoms of bacterial ring rot (Nelson 1973).

Post Harvest Control - Some type of off season indexing is present in nearly every seed program. In the positive selection programs single tubers are examined for the presence of all pathogens. These "pathogen free" plants then serve as the basic seed stocks.

In the negative selection programs the winter indexing programs eliminate lines or seed stocks from further increase which show a build up of too many diseased plants. This type of seed stock roguing is similar to field roguing of individual diseased plants in the summer months.

There are certain limitations with the post harvest control programs in each system. With positive selection the lines may become infected during the increase steps and in the negative selection infections may be missed during the indexing procedures. Leaf roll may go undetected. In one program 25.4 percent of the plants passed mild leaf roll strains (Wright, N.S. et al). Late season infections might not be detected. Small tubers that are used in the indexing program are only half as likely to contain PVY infection as larger tubers (Beemster 1967). The bud eye of the tuber seems to be the best eye to use for PLRV indexing. Plants from this eye have the strongest leaf roll symptoms (Hoyman 1962). In examining partially PVX infected tubers Beemster (1958) found

the apical eyes contained a 63 percent infection while the base eye 30 percent. However, Wright (1974) reported no difference in in frequency and eye position for the PVX virus in the Russet Burbank.

One point that should be kept in mind during the index sampling or field examination in the negative selection system is the probability of detecting diseased plants. This is influenced by both the sample size and the frequency of infected plants as both increase the sampling error decreases. (Fernow 1944).

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PRESENT SEED PRODUCTION TECHNOLOGY IN THE U.S. AND CANADA

Paul J. Eastman

Just about within my lifetime the technology of seed potato production has advanced from a system of groping in the dark to a situation where technical knowledge far exceeds the practical application of that knowledge. Today, those involved in devising new seed production programs have a wide scope of knowledge about the various causal factors of the deterioration of seed quality. Their job, as I see it, is to assess the problems which exist and then make a determination as to how sophisticated their programs can be in the light of the economics involved.

Going back to the time when my native State of Maine might have been considered a developing country as for potato production, it might be interesting to quote from some published thoughts on the subject of potatoes. In 1901 a bulletin of the Maine Board of Agriculture opened with the following general statement,"The importance of the Potato Crop is fully realized by but very few people. In fact, it has become the principal food crop of modern times. It is consumed nearly every day in the year upon the tables of the rich and of the poor. It is a staple food for the masses in all countries".

Further on in this bulletin reference is made to two major potato problems. "The Potato Disease" described Late Blight and "The Potato Beetle" referred of course to the Colorado Potato Beetle. No other specific diseases were mentioned. That year, 49,000 acres of potatoes were produced in Maine at a yield of 126 Bu./Acre and valued at .49 per bushel. No mention was made of seed problems and a significant portion of the Maine crop was sold for use as seed in southern areas.

Another bulletin published in 1914 told a different story. "There is danger of a total loss of this seed potato market due to the prevalence of disease and to impurities as to varieties.

Worst of the common diseases is Blackleg" -- The article goes on "Strict rules will be drawn up by the association, and rigid inspections made by trained men in the employ of the state". This was the statement of intent which led to the start of a certification program that very year in Maine. It should be kept in mind that this action was taken in 1914 in an area well suited to seed production because of its northerly location and isolation from other potatoes. It has already been pretty well conceded without really knowing why that seed potatoes could not be maintained in southern areas but needed to be brought to warmer climates from cooler ones. Technical knowledge was not enough advanced at that time to explain the reason; it had been observed by potato growers that things were that way.

It might be of interest at this point to ask ourselves if the pattern of seed production in the United States would have developed any differently had the technical knowledge we now have been available at that time.

With this brief introduction I will proceed to attempt a description of seed production as now practiced in the U.S.

Potatoes are grown commercially in every state of the U.S. Seed for these plantings is generally produced in the band of states across the northern U.S. from Maine to Washington and the adjoining Canadian provinces, with some seed production extending down into the central part of the nation. Altitude as well as latitude can influence the suitability of an area to produce seed.

The policing of seed potato quality in the U.S. rests with the individual states, with various agencies being granted the authority to certify under state law. In States having such programs, the service is supported mostly by fees charged to growers who participate. While regulations and procedures vary from State to State, there is general uniformity of purpose throughout these programs. The overall goal of seed certification is to produce a product uniform as to variety and free enough of seed-borne diseases and pests so that the commercial crop produced will not be damaged as to yield or quality. Certified seed is not generally intended to be suitable for producing another crop of seed, but in many cases it may be fully adequate for this purpose. The various agencies do not agree very well in the terminology used to identify higher grades of seed intended for use in producing further crops of seed. Terms including foundation, elite, premier and others, are used individually by various states and

it is necessary to study the regulations of each State to determine what each means. Virus-free and virus tested have also become fairly common descriptive terms which again must be studied to determine their meaning in each State where used.

In the United States, the disease causing the most rejections for seed and which is a constant threat to every seed grower, is Bacterial Ring Rot. The commonly accepted practice of planting seed cut from relatively large tubers in the U.S. has undoubtedly been a contributing factor in the dissemination and persistence of this disease. Lest we get the wrong idea about this disease, I would hasten to add that certification agencies have done a very effective job of policing and I do not believe that substantial losses from this disease occur very often when certified seed is planted. The actual losses from this disease are usually borne by the seed growers and usually result from low levels of infection which do not materially damage the crop for other uses. There continue to be cases of serious commercial losses from this disease, where control practices are ignored or common seed is planted.

Of next importance in seed production in the United States are the common virus diseases caused by virus Leaf Roll and the potato viruses A, X, Y and Spindle Tuber. Probably virus Leaf Roll, with its propensity for spread via the green peach aphid, is the most troublesome of this group. Spindle Tuber becomes a problem at times because of its rather obscure symptoms and its ease of spread by foliar contact. Since no insect seems to spread this disease with any degree of proficiency, the development of seed lots completely free from the virus is an effective method of wiping it out.

Of great importance to seed growers and commercial growers alike, are a group of diseases which probably are mainly tuber-borne but which are greatly influenced in their degree of damage by environmental factors and seed handling procedures. I refer here to Blackleg, Fusarium, Common Scab, Rhizoctonia, Verticillium Wilt, Silver Scurf, Skin Spot and others too numerous to mention.

I believe that Blackleg and Fusarium decay are generally responsible for more losses to all classes of growers in the U.S. than any other diseases. I hesitate to guess which causes the most losses. In all honesty, I also feel that to this point in time, certification programs have been relatively unsuccessful

in preventing these losses. Blackleg has been studied and means for its control or prevention sought for many years. It seems that only just within the last few years have we really seen the light as to the true nature of this disease and its normal life cycle. It certainly appears now that it may well be almost completely seed-borne with its expression being controlled greatly by seed handling methods and environmental conditions. It remains to be seen whether or not we can apply the knowledge we now have to commercial practice and successfully eliminate or markedly reduce the losses now being caused by this disease. Certainly the methods now proven to obtain clean seed stocks need to be put into practice and all possible effort be put forth in developing ways to maintain disease-free lots up to the level of commercial production. This may prove relatively easy in some seed producing areas and much more difficult in others. Certainly there is a great amount of grower education necessary in any area to achieve this. The use of stem cuttings in the propagation of basic stocks is becoming a reality in many programs in both Canada and the United States.

Fusarium decay of seed tubers in storage, in transit and after planting, causes losses to all involved in the seed trade - from the seed grower to the commercial grower. It may result in loss of seed from decay at any point. Many times it is the cause of poor stands at the commercial level, which results in reduced yields. Again I must admit that seed certification agencies have been less than successful in preventing losses from this cause. The organism involved is quite generally present wherever potatoes are grown and a whole gamut of environmental factors and handling practices interact in determining when it may develop into a serious problem. Various seed treatments have shown some benefit and there are indications that some new chemicals may offer more assistance in the future. These, coupled with better handling and educated storage environmental control, seem to offer out best hopes for improvement in the future.

Common Scab, long believed to be controllable by manipulation of soil PH, has shown some propensity for ignoring PH in recent years. While the outbreaks have been sporadic and not long-lived, there have been cases of so called uncommon Scab which thrives at a low PH and is readily transmitted by infected seed. Chemical seed treatment have proven effective in control.

With regard to most of this last category of diseases, it is fairly safe to generalize and say that longer rotations would

assist in their control.

Receiving broad attention in the United States at the present time are the latent viruses X, S and M, which do not exhibit recognizable symptoms in most common U.S. varieties. While their effect upon yield is not thoroughly known, it is generally believed that yield would be greater, if none of them were present. Programs for the elimination of X have been in operation in the U.S. for over 25 years, but efforts to eliminate S and M have started more recently. Any well conceived program designed to eliminate these viruses from potato stocks and maintain disease-free lots is certainly a creditable undertaking. If freedom from Blackleg can be attained and maintained at the same time, the seed industry will have made a giant step forward. If the maintenance of lots free from X, S and M proves to be virtually impossible for any period of time and Blackleg reinfects these lots at a rapid rate, one might find grounds to question the validity of expending tremendous funds and effort in pursuing the disease-free route.

In several States in the U.S. and some provinces of Canada, publically operated seed farms have been established to provide seed growers with improved strains of seed as free from disease as possible. Wisconsin and Maine have operated such farms for over 25 years and were really pioneers in this respect. The early reasons for such projects were mainly to assure a source of seed free from bacterial Ring rot and to keep the common potato virus diseases under control. Virus X was of concern also and some of the newer varieties have been maintained virtually X free for this period of time. With many of the older varieties which were universally infected with X virus, selective indexing was used to select tubers carrying the weaker race of X, which were multiplied and fed into the seed production channels. In Maine the Kennebec variety was produced essentially X free for several years. It appeared that once this seed was placed in growers' hands who were also producing old varieties universally carrying X, it was not long before reinfection had taken place. This led us to change to a Kennebec seed lot universally infected with a weak strain of X. Repeated yield trials showed no difference between this seed and the free Kennebec. For over ten years Kennebec seed universally infected with weak X has been distributed to Maine seed growers with what seem to have been better results than had been obtained with X free stock. Cross protection against the stronger races of X appears to have held up very well.

The availability of X free material of all varieties now possible through various techniques of meristem cultures, thanks in great part to Dr. Wright, puts a new question before people involved in seed improvement in North America.

Is complete freedom from X and other latent virus diseases in all varieties an attainable goal and, if so, is it a practical one? This question seems well on its way to being answered in the Western U.S. and Canada. Dr. Wright's source of clean seed is on its way to commercial channels and I would say that a good chance for success exists there.

In the East, and particularly in Maine and New Brunswick, I do not have as much confidence of success. With extensive acreages of X infected varieties being grown in the area in close proximity to seed field, I fear rather rapid reinfection. We, in Maine, are ready to try and only time will tell how successful we may be.

The publically operated seed source farms now in existence in several states and provinces are ideally suited to the job of eliminating all known diseases from their seed lots and disseminating these lots into commercial channels. I believe that each seed producing area needs to thoughtfully assess its chances of success in this effort, and through field trials and extensive testing determine the benefits to be gained. With this information at hand it will then be possible to make a realistic judgement on what course to follow.

In my opinion the Leaf roll problem now being encountered rather generally in North America, is of more immediate concern than complete freedom from the latent virus diseases. In Maine over the past three years, we have witnessed the serious spread of virus Leaf Roll march north into our best seed areas. Our efforts to control the vector late in the season seem to have been less than successful. A good program of insecticide use combined with relatively early harvesting seem to be the only way to avoid serious Leaf roll spread except for the Northern most area of Maine. Newer insecticides now coming into use may help correct this problem and the cycle may have reached its peak, but we have not yet seen either of these proven. The green peach aphid is a formidable adversary and it remains to be seen who will emerge victorious.

This leads me to a brief discussion of Southern testing as a tool in certification.

In Maine, Southern testing of seed lot samples was started in 1937. The purpose then, as now, was to determine the level of current season spread of the common potato virus diseases by growing samples in the winter plots. Samples planted in South Florida in November are generally ready for reliable disease readings January 1. This means that poor lots can be spotted and discarded for seed before planting time in a greater part of the U.S. production area. Originally these tests were designed to serve the seed grower in determining what lots he should plant for his next year's seed production. In Maine it has become a widely used measure of seed quality for commercial seed lots.

The result of Maine's Southern test are a major criteria for designation as foundation seed. Any Maine seed lot otherwise qualified for foundation designation must be represented in the Southern test and show a common virus reading of not over .5%. A maximum Southern test reading has at times been applied as part of requirements for certified seed. This is an extreme control measure for the seed grower because it limits early sales for future delivery. Results from Florida are not usually available to growers until late in January. This means that sales of certified stock would be impossible to Southern areas if certification were based upon Southern test results. However, the application of the Southern test to foundation seed has worked quite satisfactorily.

From our experience in Maine, the Southern test has been of great value. Some of the most important contributions it has made are as follows:

1. It gives advance information on trends in virus spread.

2. It avoids the planting in Maine of seed lots which from their history and field reading in Maine, appear to be excellent but which have received heavy current season spread of a common virus.

3. It has contributed largely to the virtual elimination of spindle tuber from Maine seed stocks.

4. In our present struggle to limit Leaf roll spread, the information gained from the Southern test is of tremendous value.

For a cost of $1.75 per acre a Maine seed grower can get a reliable Southern test reading which truly reflects the common virus

content of the seed crop he has in storage. In any period when Leaf roll spread is rampant, this information can be of great value to seller and buyer alike.

Considerable research in Maine has indicated the practicality of using the Southern plots for conducting tests on the latent virus diseases previously mentioned in this paper. Here again, such tests conducted on these plots would more truly reflect the level of infection actually present in a seed lot because any current spread would be included. This might not be true if tests were done in the field in the production area.

I believe that the Southern test has been an extremely useful tool in seed improvement and certification and that it can continue in this role even as disease elimination programs become more and more sophisticated.

There are about twelve states and provinces in Canada which use a Southern test in conjunction with their seed improvement programs.

In the United States and Canada the problem of physiological age and storage period do not seem as serious as in other parts of the world. The seed production areas generally can store seed for periods up to nine months without use of refrigeration. In our southern most production areas where plantings may take place very shortly after harvest in the seed area, there is sometimes need to break dormancy but generally the varieties used perform satisfactorily without this treatment. In Southern tests where varieties with long periods of dormancy are tested it is necessary to use a chemical treatment in order to get rapid growth. In some areas of California the matter of physiological age has been of concern but not to a major degree in seed performance.

While I have referred to Canada in several instances I should be more specific as to some of the differences between Canada and the U.S. In Canada, potato seed certification is controlled by the Federal Government with uniform standards being applied to all provinces. The costs of the service are generally borne by the government rather than the grower, as in the U.S. The government registers the varieties approved for certification and only those registered are eligible.

The maritime provinces of Canada have traditionally been deeply involved in export of seed potatoes to the U.S., Central

and South America, the Caribbean, Europe, Asia and Africa. They have fostered this trade and have coped with more problems attendant to physiological age, ocean shipping and satisfying the demands as to seed size and grade of other countries than have U.S. seed potato people.

As to production techniques and seed improvement programs, the Canadian programs are not greatly dissimilar to those in the U.S. It is true that Dr. Wright in British Columbia has pioneered the work on latent virus freedom in North America. His lead has been followed by both U.S. and Canadian programs. Several Canadian provinces have established seed source farms similar to those previously mentioned in this paper.

A rather unique program is now under way involving the province of New Brunswick and the State of Maine. Their potato areas are near together, being separated at places only by the St. John River. They share most seed production problems. A joint task force between the two has worked out a cooperative program to cope with the green peach aphid and leaf roll spread. This joint effort in coping with production problems is an international endeavor and as such is a bit unusual because in the seed potato markets the two countries are competitors.

The sharing of knowledge and the cooperative effort developing in this program bids fair to achieve some success in the control of this important problem.

CONCLUSIONS

In summary of U.S. seed potato certification, I would pose the following conclusions:

1. Bacterial Ring rot will continue to plague the industry in the forseeable future and must be dealt with in the ways well known to us all.

2. Control of the common virus diseases Leaf roll, Mosaic and Spindle tuber, remain of top priority.

3. Increased research and application thereof is called for in dealing more effectively with Blackleg, Fusarium and the other diseases classed together previously.

4. The ideal of complete disease freedom, as mentioned previously should be studied and tried within the capabilities of the services involved, but it should be remembered that freedom from disease is not immunity.

5. Active breeding programs will continue to solve some seed problems through disease and pest resistance built into new varieties. It is doubtful, however, if the ideal variety-resistant to everything good will ever be assembled. New varieties for specific areas and purposes will continue to help solve the many problems of seed quality maintenance.

As potato growing becomes an industry made up of larger and larger units with careful control of all factors relating to production, the seed potato business will become more and more sophisticated. There will still be a place for organized seed source farms employing all of the advanced technology available. Southern testing will continue to play a valid role as long as current season virus spread is a problem. With all kinds of new testing procedures and disease eliminating processes, the seed grower himself is likely to remain the most important key to better seed potatoes for planting the commercial potato acreage.

Highly advanced technology in disease elimination can only pay off if the seed growers multiplying the improved seed lots are entirely aware of the dangers of re-infection and are capable and willing to do the necessary things to prevent it.

PRESENT SEED PRODUCTION TECHNOLOGY IN EUROPE

E. R. Keller

Europe is not a continent with uniform conditions for seed potato production. An attempt has been made therefore to survey production methods in various countries: France, Germany F.R., The Netherlands, Scotland and Switzerland. Where it is possible, subjects are treated for each country under uniform headings. This contribution refers to conditions in Western Europe only.

A. Definition of seed types.

Rules for the certification of seed potatoes were set up by the UN-Economics Commission for Europe. They serve as guide lines for the members. The Common Market however has accepted them as a mandatory frame work in an attempt to unify the various systems. Individual members of the Common Market, i.e. may have their own norms, as long as they are as stringent as CM-standards.

Basic Seed	produced by means of clonal propagation (authenticity of variety). assigned for the production of certified seed.
Certified Seed:	direct offspring from basic seed, from certified seed, or from an older generation than basic seed which at an official inspection met the conditions for basic seed.

The minimum demands which seed material must fulfill are as follows:

1. Basic material

(a) In official field inspections the percentage of plants infected with Blackleg may not exceed 2.0%.

(b) In the direct offspring the percentage of atypical plants may not exceed 0.25% and the percentage of other varieties may not exceed 0.1%.

(c) In the direct offspring the percentage of plants which show symptoms of serious or mild virus diseases must not exceed 4.0%.

2. Certified seed material

(a) In official field inspections the percentage of plants infected with Blackleg may not exceed 4.0%.

(b) In the direct offspring the percentage of atypical plants may not exceed 0.5% and the percentage of other varieties may not exceed 0.2%.

(c) In the direct offspring the percentage of plants which show symptoms of serious or mild virus diseases may not exceed 10.0%. Mild mosaic diseases, that is to say mere discolouration without malformation of the leaves, is not taken into consideration.

3. In estimating the offspring of a variety which is infected with a chronic disease, the mild symptoms caused by the virus in question will not be taken into consideration.

4. The tolerances mentioned in point 1 (c), point 2 (c) and point 3 may be applied only to virus diseases which arise from viruses which are widespread in Europe.

5. The field for production is free from Heterodera rostochiensis Woll.

6. The crop is free from:

(a) Synchytrium endobioticum (Schilb.) Perc.

(b) Corynebacterium sepedonicum (Spieck et Kotth., Skapt. and Borkh.).

Minumum demands for the quality of lots of seed material

- Limits tolerated for the following impurities, shortcomings and diseases in seed material:

1. Occurrence of soil and foreign substances, 2% of the weight;

2. Dry rot and soft rot to the extent that they are not the result of _Synchytrium endobioticum_, _Corynebacterium sepedonicum_ or _Pseudomonas solanacearum_, 1% of the weight;

3. External defects (e.g., malformed or damaged tubers), 3% of the weight;

4. Potato scab: tubers which are infected on more than 1/3 of the surface, 5% of the weight.

Total limits of tolerance for points 2 to 4, 6% of the weight.

- Seed potatoes must be free from _Heterodera rostochiensis_, _Synchytrium endobioticum_, _Corynebacterium sepedonicum_ and _Pseudomonas solanacearum_.

B. Production Sequence and Distribution of Seed.

1. Selection of initial material

In countries with clonal propagation, procedures to secure quality of initial material were considerably improved. Normally, clonal selection is based on single tubers or eye cuttings tested for virus infections. Where seed-borne diseases such as blackleg, skin spot and gangrene cause severe problems, the techniques of stem cuttings has been introduced (Scotland, Denmark). Disease-free cuttings are rooted in a propagator normally heated to 21° C during 10 - 12 days. Thereafter the cuttings are transplanted to pots and, after a hardening - off period, are planted in field drills to complete growth and tuber development (VTSC).

2. Site selection and planting methods

Site selection is not only a problem limited to the choice of best climatic conditions. The following points should be kept in mind.

- number and species of virus vectors and cycle of development. Most favourable conditions are found in coastal regions (f.i. Bretagne, Netherlands, Northern Germany incl. Pomerania, Ireland, Scotland). Less favourable conditions are found in higher altitudes. High altitudes are not suitable due to the fact that vectors from lowlands might be brought up by air currents relatively early in the season. This does not fit with the relative late planting time of the potatoes (no mature-plant resistance, no effect of haulm killing).

- occurrence of virus infected plants in potato fields for ware production. The advantages of the formation of "closed regions" (geschlossene Lagen, bassins fermés, protected zones) are incontestable and should be utilized from the beginning.

- in regions with mild winter temperatures or at high altitudes with early snow fall (and no soil frost) plants from overwintering tubers may cause some danger (virus infection, purity of the variety, nematodes, etc.).

- adequate soil conditions, experience with arable crops and knowledge of the farmers may appreciate or devaluate the properties of a "suitable" region to a great extent.

Planting methods

- Density of hills should be considered an effective means to control tuber size of seed harvested (55 - 60'000 plants/ha).

- Accuracy of automatic planters still needs to be improved.

- Prevention of mechanical damage to the sprouts is of special importance when seed potato prodcution is combined with the so-called early harvest, i.e. haulm destruction.

- Use of whole tubers, size 35 - 45 mm. ev. 35 - 50 mm or in favourable conditions 28 - 35 mm.

3. Cultural practices

Seedbed preparation: It is not possible to give here detailed information, since necessity of autumn or spring ploughing is dependent on factors and experience not uniform in Europe.

However, the intention is clear: potatoes require an active soil in good structure without clods, with sufficient depth and water-holding capacity. The building up of a sufficient ridge is important.

Manuring: Farm manuere in autumn (except on sandy soils), no excessive rates of N but abundant rates of P (soluble forms) and K (prevent harmful effect of Cl). Pay attention to Mg-deficiency.

Chitting or adequate pregermination is indispensable in successful seed potato production. Without pregermination we cannot realize the advantages of mature-plant resistance, regular growth at roguing, yield and tuber size at date for haulm destruction. Pregermination is also necessary in order to recognize and eliminate diseased tubers or those with not sufficient germination should be guided in such a way that many sprouts start to grow.

Isolation of seed potato fields certainly is not a reliable measure to avoid virus infections, but it may help where it is not possible to create closed regions for seed production.

Border rows (1 - 2) of certified fields should not be harvested as seed when there is danger of virus infections from neighbouring fields.

Roguing of diseased plants has to take place early, radical and accurate, and repeated several times. Roguing-out refers to all plants which do not look healthy!

One of the secrets of successful seed potato production in the Netherlands is effectiveness of roguing. The grower or the specialist in charge of roguing must be able to decide whether or not a field should be rogued. If there are more than 2% of virus infected plants in a field, roguing is more than questionable (production of certified seed). Selection of outstanding lots is therefore very important for the production of certified seed under not really favourable conditions. It is possible to improve the effectiveness of roguing by eliminating the diseased plant and the two neighbour plants in the same row.

Application of systemic insecticides can be of some help, but one should first investigate the suitableness of a treatment since the effectiveness is dependent on several factors.

Haulm destruction in order to prevent virus migration in primarily infected plants into the tubers is in many cases a very effective measure to improve quality of the seed. Tuber infections due to early spring flight (i.e., migration of *Myzus persicae* into the fields) are not prevented. The most reliable method of haulm destruction is the pulling-out by hand, still possible to practice where labour is available and not expensive. Chemical treatment is of course much more convenient but always slower in action. Regrowth of shoots is very detrimental. It is clear that early haulm destruction reduces the total yield but increases the yield in seed size. The price obtained for such seed therefore is of great importance.

Dates for haulm destruction should be based on the development of the aphid population (different methods are possible). Certainly some experience is needed to adjust dates to different regions, considering local conditions, differences in altitude, resistance of varieties, tuber development, etc. There is some danger of a negative influence on the germinative power by too early haulm destruction but in practice damage seldom occurs.

4. Sanitation, inspection and quarantine

See independent chapters: France
Germany, Federal Republic
Netherlands
Scotland
Switzerland

5. Harvesting and storage

- Harvest under European conditions is possible 10 - 14 days after complete haulm destruction, i.e. when tubers have a firm skin.

- Time of harvest is dependent on many factors, but seed potatoes should be harvested in time to prevent an accumulation of sclerotia of *Rhizoctonia solani*.

- To minimize losses from fungal and bacterial diseases during storage: no mechanical damage, storage of clean tubers in rather small boxes after a would-healing period, never decrease temperature too fast, keep storage boxes and machinery clean, etc.

Since treatment of tubers in order to prevent tuber diseases is still an unsolved problem, emphasis should be put on precise regulations for clonal propagation (stem cuttings) as well as for the production of certified seed (rotation, roguing of black-leg, bulk inspection).

6. New approaches being introduced

Introduced or being studied in some European countries are:

- methods of stem cutting

- methods of meristem culture

- A6-leaf test and Igel-Lange test as cheap methods with high capacity for the detection especially of PVY (leaf and tuber) and PLRV (tuber).

- improvements in breaking dormancy for an early establishment of the autumn-field test with or without plastic tunnels. Decapitation for PLRV is also being studied.

Final remarks

It is clear that problems in tropical or subtropical countries are quite different from those in Europe. The same is true for regulations to introduce and develop seed potato production. We therefore cannot expect the same success with the same methods. Although they do not guarantee perfection, one should start under such circumstances with relatively simple working methods: i.e., not necessarily with breeding or clonal selection. The courage to renounce perfection is in many cases the first successful step.

Literature

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SEED POTATO PRODUCTION IN SCOTLAND

E. R. Keller

1. General

Conditions to produce seed potatoes in Scotland are in some ways different from those in other European countries, such as France, Germany or the Netherlands. Aphid-transmitted viruses are not a problem under Scottish climatic conditions, so post-cropping tests for PLRV and PVY are not necessary. On the other hand, these cool and damp conditions increase fungal infections. For this reason a program was started in 1967 to control skin spot, gangrene and blackleg by means of stem cuttings and clonal selection.

The stem cuttings taken from selected mother-plants and completely tested for the presence of virus, blackleg and phoma grown at a central station under insect-proof conditions.

In the following year clones are propagated on one farm in the "high grade seed area" in a field in which potatoes had not been grown before.

In Scotland only the following grades are produced:

- virus-tested, stem-cutting seed (V.T.S.C.)
- Foundation seed (F.S.); equal to SE in other countries
- AA

All three grades = basic seed.

In other regions (Wales, England) commercial certified = C.C. seed is produced, but no basic seed.

The Department of Agriculture and Fisheries (Agricultural Scientific Services, East Craigs, Edinburgh) is responsible for certification of seed potatoes.

2. Production of virus-tested stem-cutting stocks (V.T.S.C.)

All stocks must be raised by clonal selection and must start from tubers supplied by the Department of Agriculture and produced by the Department from stem-cuttings tested for the presence of viruses and for *Erwinia carotovora*.

Approved growers must continue to propagate in clones the tubers which are supplied annually. They have to also test them yearly for PVX, PVS and PVM. The Department gives instructions in methods of testing and provides the serum. The Agricultural Scientific Service itself tests the clones for other viruses, e.g. PVY and PVYN and generally supervises the grower's production program.

Preliminary conditions, rules of testing, procedure:

The grower's facilities and his method of testing must be satisfactory to the Department. All stocks must be raised from the initial material supplied by the Department and must, at a minimum, be tested by the grower, in the following manner:

a. First Year. The tubers obtained from the Department must be grown as clones and two leaflets from each plant must be tested.

b. Second Year. The produce of first year selections must still be grown as clones and at least two leaflets from each plant must be tested.

c. Third, fourth and fifth years. The crop should be sampled at random and at least one leaflet from each of 600 plants per acre must be tested in the third year; from 300 in the fourth year and 100 in the fifth year. In addition, all doubtful plants must be tested individually. Crops may not be entered for certification before the third year (exceptionally in the second year) or after the fifth year. Bulking of clones should be done, preferably, only after certification; if earlier bulking is found necessary, growers must obtain permission from the Department and give details of the clones being bulked.

If, in exceptional circumstances clones of different ages are bulked, testing must conform to that laid down for the youngest clone, while the eligibility of the bulked stock for inspection will be determined by the age of the oldest clone.

d. Testing in Bulk. For the biological test not more than 20 leaflets may be bulked to constitute one test sample; for the "slide agglutination" test, not more than 5 leaflets may be bulked.

e. Records of Testing: details see Memorandum RE 29383/2 ZBL.

f. Extent of Crop. The acreage of any variety entered for inspection shall not be less than 0.25 acre but may be made up of an aggregate of clones.

g. Rotation. The land on which VTSC stocks are growing shall not have grown a potato crop during the preceding seven years.

h. Isolation. A crop submitted for VTSC certification must be separated by at least two drills from any other stem-cutting clone being built up and tested and there must be no potato stocks other than those derived from stem-cuttings in the field. (Any other potato crops grown on the farm in 1974 must be planted with seed certified in 1973, or with the produce of tested nursery clones).

Potatoes must not be grown in any garden on the grower's farm.

Field inspections

a. Number. Not less than two inspections of the growing crop shall be made by the Department.

b. Leaf Testing. Leaf samples taken by the Department from the growing crop must be found on examination to be free from viruses S and X infection and from infection of any other important virus.

c. Destruction of Foliage. If required by the Department the foliage shall be destroyed within a specified period.

d. Inspection Tolerances.

Roguing before Inspection:

- Roguing must not be started until authorized by an Inspector,
- following a preliminary examination of the crop, if required by the inspector,
- thereafter not more than 30 plants per acre may be removed prior to final inspection.

- All plants removed for virus infection (other than leaf-roll) or because of suspect symptoms must be tested and recorded.

Purity and Trueness to type:

- No rogues or recognizable variations at final inspection.

Ground-Keepers:

- None.

Potato Cyst Eelworm:

- None (precropping soil test necessary).

Certification:

Crops will be awarded provisional VTSC certificates, following Growing Crop Inspection, provided the requirements of the grade have been met. All consignments of seed tubers from crops which have been provisionally certified as VTSC must be submitted for final certification labelling and sealing prior to sale in terms of the Scheme. Final certification will be dependent upon each consignment meeting the required standards of tuber health. These standards are available on request.

Fumigation of tubers:

In order to ensure no re-infection with skin spot and gangrene, fumigation with secondary butylamine (2-amino-butane) within two weeks of harvest is practiced. Much importance is given to clean (disinfected) machinery and storage facilities.

3. Production of seed potatoes other than VTSC

Field inspections: see scheme Table 1.

Roguing: Crops should be rogued as soon as growth permits. Rogued plants should be removed from the field. Where tubers have been left in the ground after roguing, the rogued plants will be recorded as though they had been severely diseased.

Foundation seed class (FS) can be grown by anyone and testing by the grower is not necessary. However, during the examination of the growing crop the inspectors conduct serological tests on any plants suspected of being virus-infected. Stocks will be certified at Foundation seed level for not more than four years.

Class AA : visual examination, requires no testing.

Haulm destruction: no fixed dates in Scotland.

Rotation and soil test: For FS and AA no potato crop in the previous five years. Precropping soil test is necessary.

On any farm where seed for certification is grown, all other potato crops must be planted with certified seed.

Storage: Tubers from crops of different grades or different varieties must be pitted in separate pits or, if stored in sheds, must be wholly and clearly separated, for example, by straw balls or timber. Each stock must be clearly identified. Failure to observe these conditions will result in the withdrawal of the certificate.

Bulk inspection: All certified stocks must be submitted for compulsory labelling and examination and the bags or other containers in which the seed is to be dispatched must bear the official label. Sealing is required for export.

Literature

Hardie, J.L.: Potato growers' guide to clonal selection.

Hardie, J.L.: Potato growers' guide to commercial seed production.

Hardie, J.L.: Agricultural Scientific Services, East Craigs, Edinburgh, (personal communication) as well as Memorandum RE 8330 TBL, RE 29383/2 TBL, RE 29384 TCL.

Table 1 Crop Certification Standards and Requirements 1974

Certificate	Origin of Seed	Area	Purity and Trueness to Type (minimum standard)	Inspection	Maximum Tolerances allowed for purposes of Crop Certification											
					Rogues and Ground Keepers	Undesirable Variations and Wildings	Bolters	Semi-Bolters	Leafroll	Severe Mosaic	Veinal Necrosis	Mild Mosaic	Blackleg	Witches Broom	Potato Cyst Eelworm	Roguing
Foundation Seed (FS)	Virus-tested Stem-cutting Seed or Foundation Seed certified in 1973	Not less than 0.5 acre	99.95%	1st	← 0.05% →			0.5%	0.02% including only 0.01% of Severe Mosaic		None	0.05% including all mottles	0.25%	(not considered)	None	1% maximum
				2nd or final	← 0.05% →				0.01%	None	None	0.05% including all mottles	0.25%	0.02%	None	no maximum
Grade 'AA'	Seed certified in 1973 in grades FS or AA	not less	99.9%	one	0.1%			(not considered	0.25%		None	2%	1%	0.25%	None	2% maximum

Separations (minimum): FS: A separation of two drills at planting is required between crops entered for Foundation Seed inspection. Where adjacent crops are not entered for Foundation Seed inspection, a four drill separation is necessary. For other details not mentioned here, see Memorandum RE 29384 TBL.

AA: 2 drills (at planting) from any other potatoes except Foundation Seed.

PRODUCTION OF SEED POTATOES IN THE NETHERLANDS

E. R. Keller

Summary from: J. Hiddema, Inspection and quality grading of seed potatoes, published in the Bokx: "Viruses of potatoes and seed-potato production".

Wageningen, 1972

1. Organization of seed potato production

Commercialization is limited to seed potatoes provided with certificate and lead seal. The Vereeniging Nederlandsche Algemeene Keuringsdienst (NAK) has direction from the government to inspect agricultural and horticultural crops. The board of NAK represents breeders, traders, growers and consumers. NAK is under government supervision. Regulations for inspection and certification are given by the central NAK office in Wageningen. The directives are put into effect by the regional inspection services.

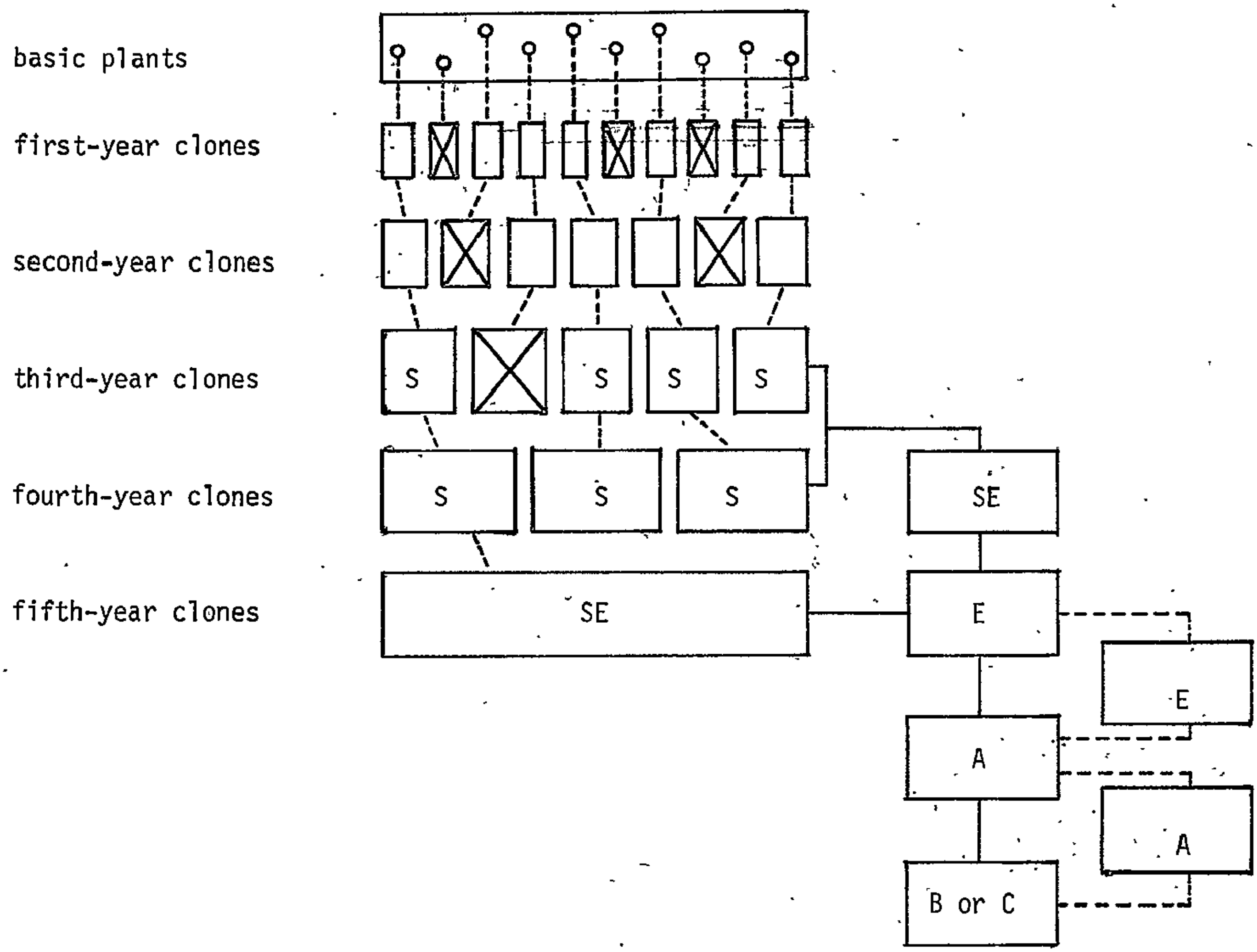
2. Comments on the scheme of clonal propagation of seed potatoes.

Basic plants are chosen from 3-, 4- or 5-year clones in the field and tested before early harvest on PVX, PVS and PVM.

Tests on the clones are for PVM, PVS and PVX (serology), PVA and PVY (A6-leaf test). Clones are checked during growth, 8 - 11 weeks after planting. Of the first-year clones all stems of each plant are tested. Of the second-year clones about half the plants are tested; 100 plants are tested from the clones in the third, fourth and fifth year. For each test sap from two leaves is used. In the first and second year clones are rejected if only one virus test is positive. Positive tests in older clones affect their grading.

Varietal type of clones is checked both regionally and centrally. Every year the central service of NAK lays out a clonal field and optionally the regional inspection services does so as well. A clone cannot be classified S unless at least one sample of it has grown on the central field. The plots of 21 plants are under continuous observation by trained inspectors, who check for diseases and for varietal type. Deviant clones and clones with deviant plants are rejected as basic seed.

Scheme of clonal propagation of seed potatoes in the Netherlands



X : Rejected at field inspection, serological test, judgment on type or tuber indexing.

___ : Crop is passed to the grower.

- - : Crop is replanted by the grower.

S, SE, E, A, B and C: quality grades of seed potatoes.

From: J. Hiddema, Inspection and quality grading of seed potatoes, published in de Bokx, Viruses of potatoes and seed-potato production. Wageningen, 1972.

3. Field inspection

Summary of the most important requirements:
Varietal purity: S, SE, E and A may not contain any mutants or deviants;
purity must be 100%; grade B must be 99,5% pure

Factors applied by inspectors in assessing incidence of diseases at the first (1st) and the later inspections

	Basic seed				Certified seed	
	S and SE		E		A and B	
	1st	later	1st	later	1st	later
Potato stipple streak, crinkle	32	64	16	32	16	32
Severe mosaic	32	64	16	32	8	16
Mild mosaic	32	64	16	32	1	1
Leafroll	8	32	8	32	8	32
Aucuba mosaic, stem mottle	4	8	4	8	2	6
Verticillium wilt	1	1	1	1	1	1
Suspect	1	2	1	2	1	2
Gaps	0,5	-	0,5	-	0,5	-

The sum of the products (incidence x factor) is the disease index of the field. At four places in the field, the inspector examines 100 plants and counts how many are diseased.

The figure for each disease is multiplied by the above mentioned factor. Maximum index for the different grades are: S and SE= 2; E = 3; A = 4; B = 8.

Blackleg (*Erwinia atroseptica*), if present or rogued, crops are not graded S, SE or E.

Surroundings: A crop is graded lower if an adjoining field can act as a source of virus infection.

Field inspection is considered to be the most important control.

4. Dates for haulm destruction

As soon as aphid flights are a threat the NAK central office suggests dates for haulm destruction. They are passed to the regional inspector services who inform the growers as soon as possible. Dates are never fixed earlier than about 10 days after large flights of aphids have been monitored. Dates for haulm destruction are compulsory for grades S and SE. For grade E the regional services are allowed to release special standards, the same for certified seed.

5. Control of virus infections after harvesting

In principle all inspected seed is indexed for PLRV, PVA, PVM, PVS, PVX and PVY, but NAK may, under special circumstances, exempt crops of grades A and B. Samples of 200 tubers (basic seed) and 100 tubers (certified seed) are taken in the field according to a pattern letter B.

Testing methods: The choice of the testing method is handled with flexibility. The sampled tubers may be submitted directly to the Igel-Lange test (PLVR) or are treated with either Rindite or GA to break dormancy and to grow plantlets (eye-cuttings) from them. About 4-6 weeks after planting in the greenhouse they are checked for the presence of mosaic and PLRV visually or for the presence of PVA and PVY with the A6-leaf test.

6. Bulk inspection and certification

The grower must inform the inspection service when he starts preparing the crop for transport. Each consignment is sampled for diseases and defects noted at the preliminary inspection. When the seed is ready and if it meets all standards, each bag is certified and sealed by the inspector or under his supervision. Certificates and labels are different according to the grade.

PRODUCTION OF SEED POTATOES IN GERMANY (FEDERAL REPUBLIC)

E. R. Keller

1. Organization of seed potato production

Seed potato production is based on regulations from May 1968. Breeders are responsible for propagation or multiplication until the so-called pre-multiplication (Vovermehrung). After this phase production and sale (SE, basic and certified seed) are managed by regional associations of growers or commercial firms. The authorities charged with the field inspection, the testing, the bulk inspection at delivery and the training of the producers may not be the same since the "Länder" (Bavaria, Lower Saxony, etc.) are independent in this matter.

2. Scheme for clonal propagation of seed potatoes (see page 2)

Comment

- It is possible to reproduce the pre-multiplication twice.

- Application of testing methods is different according to the "Länder". Normally, basic seed is indexed in the glasshouse with additional A6-leaf test and serology. In some regions the Igel-Lange test is applied to mosaic-resistent varieties (basic and certified seed). If haulm killing is practised at official dates, there may be no testing after harvest in Lower Saxony. Dates for haulm killing are evaluated and fixed by the authority in charge of the certification. It is recommended to kill only the haulms. Breeders usually pay an extra price for haulm-killed material produced under their control.

3. Summary of important standards

Field inspection: most important prescriptions

	Basic seed %	Certified seed %
PLRV and severe mosaic	0,2	0,6
PLRV incl. all forms of mosaic	0,4	special prescription
Blackleg	2	4

SCHEME OF CLONAL PROPAGATION OF SEED POTATOES

Germany, Fed. Rep.

<table>
<tr><th>Year</th><th>Structure of clonal propagation</th><th colspan="2">Virus tests involved</th></tr>
<tr><td>1</td><td>Pre-A-clone (single tuber or tested eye from tuber)</td><td colspan="2">Growth in the greenhouse and re-peated tests on PVX, PVY, PVA, PVS, PVM and PLRV. Authenticity.</td></tr>
<tr><td>2</td><td>A-clone with 10 hills each</td><td colspan="2">Cultivation in the field. After harvest 2 tubers of each hill are tested on PVX, PVY, PVA, PVS, PVM, PLRV.</td></tr>
<tr><td>3</td><td>Mixture of A-clones (Excep-tion: varieties with a tend-ency to phenotypical altera-tions —— B-clones)</td><td><u>Lower Saxony</u>
After harvest test-ing of a 100-tuber sample/0,25 ha, viruses see above</td><td rowspan="3"><u>Bavaria</u>
Official test 100 tubers/ 3ha eye-cutting + serology + A6-leaf test</td></tr>
<tr><td>4
or
4-6</td><td>Pre-multiplication (Vorver-mehrung)
Cultivation by the breeder under best field conditions (closed regions)</td><td rowspan="2">After harvest test-ing of a 100-tuber sample/0,5 ha; viruses see above</td></tr>
<tr><td>5
or
7</td><td>Superelite
Cultivation on few special-ized farms under best condi-tions (closed regions)</td></tr>
<tr><td>6
or
8</td><td>Basic seed
Cultivation in closed regions and on specialized farms</td><td colspan="2">Official testing of all varieties. Variable testing of virus-resistent varieties</td></tr>
<tr><td>7
or 9</td><td>Certified seed 1</td><td colspan="2">See basic seed</td></tr>
<tr><td>8
or 10</td><td>Certified seed 2</td><td colspan="2">See basic seed</td></tr>
</table>

Application of testing methods:

Pre-A-clone until Mixture of A-clones: plantlets (eye-cuttings) combined with serology and A6-leaf test.

Pre-multiplication until basic seed: plantlets (eye-cuttings) combined with serology and A6-leaf test; PVY-resistent varieties only in Igel-Lange test.

Certified seed: Igel-Lange test (Bavaria), by occurrence of abnormal mosaic-infection also in eye-cutting test.
In Lower Saxony (Niedersachsen) susceptible varieties in eye-cutting test.

Tuber testing after harvest:

Basic seed	4% (but not more than 2% severe virus diseases)
Certified seed	6%

Bulk inspection at delivery (sealing):

	max. %/weight
Occurrence of soil and foreign substances	2
Tuber rot, dry and wet	1
Mechanical damage, malformations	3
Common scab	5
Total limits of tolerances (without soil)	6

4. Miscellaneous:

- Members of CM have a common post-harvest control field (Belgium). Samples from the different countries are sent to this station and are compared for virus %, plant development, purity of the variety in order to control whether or not the CM-rules are observed.

- Systemic insecticides are applied, especially to stocks under control of the breeders.

- Seed potato surface in Germany has decreased faster than total potato surface. This was not due to technical reasons but to instability of prices. Therefore, the creation of a price-compensation system (growers, traders, consumers) is being studied. Stability of the price is considered to be an outstanding factor to guarantee the continuity of the production and to improve quality.

Literature

Hunnius W.: 35 Jahre deutsche Pflanzguterzeugung. Kartoffealbau 6, 146-47, 1972.

Hunnius W.: Personal communications.

PRODUCTION OF SEED POTATOES IN FRANCE

E. R. Keller

1. Organization of inspection and certification

Due to legislation, commercialization of seed potatoes without the agreement of the Service Officiel de Contrôle et de Certification (S.O.C.) is prohibited. The Règlement Technique in which modalities of production, control and certification are defined is issued by the Ministry of Agriculture with the assistance of the Commission Officielle de Contrôle et de Certification (C.O.C.). The Fédération Nationale des Producteurs de Plants de Pommes de Terre (FNPPPT = Federation of seed potato growers) is charged with the application of standards.

2. Scheme of clonal propagation of seed potatoes (see page 2)

3. Summary of important standards

Field inspection: max. % of all visits

SE	(3 visits)	0,25% of virus infected plants	basic seed
E	(2 visits)	0,25% " " " "	
A	(2 visits)	1,0% " " " "	certified seed
B	(2 visits)	3,0% " " " "	

Préculture (field test after harvest):

max. number of virus infected plants

SE	1	plant on	220
E	1	" "	220
A	3	" "	110
B	10	" "	110

Bulk inspection at delivery (sealing):

max. %/weight

Fusarium	0,1%
Common scab (severe symptoms)	5 %
Powdery scab	0 %
Late blight	0,1%
Other rots (dry and wet)	0,1%

No tolerance for: powdery scab, wart, bacterial wilt, potato beetle, nematodes. Phtorimea op.

Scheme of clonal propagation of seed potatoes F r a n c e

Phase of reproduction	Structure of propagation and testing involved		
	Pre-multiplication (initial stock) ↓	Tubers completely tested and grown in insect-proof cages	Cultivated in central nursery of FNPPPT at Landernau (Bretagne)
	F_0 1 plant ↓	Visual field inspection Laboratory tests after harvest: F_0 : 1 tuber per plant F_1 : 1 tuber per plant F_2 : 20 tubers taken from 20 plants	
I Selection of material	F_1 10-20 plants ↓	Tuber indexing in glass-house	
	F_2 100-200 plants ↓	Serology X,Y,S,M, PLRV with decapitation of plants, A6-leaf test Elimination of family if only one infection is ascertained	Responsible for reproduction = Syndicates of growers of FNPPPT
	F_3 2 ares	Field inspection + before planting	
	Mixture of families of same value or individual reproduction ↓		
	F_4 20 ares ↓	Field inspection + before planting	
	F_5 2 hectares ↓	Field inspection + before planting	
	F_6 ↓	Field inspection + before planting	Commercial seed
II Basic Seed	F_7 ↓	Field inspection + before planting	SE Field inspection + before planting ↓
	F_8	Field inspection + before planting	E Field inspection + before planting ↓
III Certified Seed			A Field inspection + before planting ↓ B

4. <u>Protection against virus infections (commercial seed)</u> is achieved by:

- choice of favorable regions (coastal regions, elevated regions).
- isolation from other potato fields with a minimum of 10 m; same distance between basic and certified fields.
- early and repeated roguing.
- vine killing (compulsory at fixed dates, based on development of aphid population).

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SEED POTATO PRODUCTION IN SWITZERLAND

E. R. Keller

1. Introduction

Switzerland does not belong to those countries which - due to favorable climatic conditions - are best suited for seed potato production. We concluded therefore

- that it is of advantage to defer to clonal selection (we are not breeding potato varieties).
- that it is advisable to concentrate all efforts on the production of certified seed in order to cover the total demand for seed potatoes of the country.
- that it is of advantage to develop technology of seed potato production with the aim to use only the minimum of imported basic seed.

The Swiss Federal Alcohol Board is in charge of the utilization of the potato crop. Since production of alcohol from potatoes is not allowed and since regularly production exceeds demand, authorities are concerned that seed potato production is kept as bulky as possible, thus decreasing costs for converting the surplus of ware potatoes. This is also the reason for importing only a minimum of basic seed and producing as much seed for further multiplication as possible in Switzerland. It is the intention to produce a large quantity of certified seed from a small quantity of basic seed in the shortest possible time.

In many of the developing countries with unfavorable climatic conditions the object might be the same.

2. Organization of seed potato production

The acreage for seed potato production is fixed every year by the Ministry of Agriculture after consulting all organizations interested in this matter. The 3000 seed growers, affiliated in 25 local associations, are members of the Federation of Swiss Seed

Growers which is in charge of the external control of the seed before delivery. The experts of this Federation have to affix lead seals to every bag when the seed lots were certified by the Agricultural Experimental Stations.

The local associations of the seed growers are responsible for the contracts made with their growers (members) and for the sale of the products. They also have to train their members and to examine their knowledge, e.g., on virus diseases. Finally, they have to establish the post harvest control fields (100 tubers per lot).

The Swiss Experiment Stations for Agriculture at Zürich-Reckenholz and Changins-Lausanne are responsible for the certification in the different regions according to language. They issue the prescriptions and charge the experts with the field inspections. These stations also fix the dates for haulm-killing and test the tubers of each lot in the Igel-Lange test, the A6-leaf test or in the field test after harvesting for virus diseases before final certification. They further control the quality (germinative power, virus %, and other diseases) of all certified lots in the post harvest control fields, established in the following Spring.

Seed potato merchants are obliged to buy Swiss seed - but there is no difficulty since it has been proven that the quality (virus %) and yielding ability are equal to imported basic seed (Table 1).

3. <u>Choice of suitable regions for the production</u>

Differences in topography and air currents influence the development of aphids which are vectors for virus diseases. Systematic evaluation of aphid development for twenty five years clearly showed that our favorable regions for seed potato production are located in the hills and lower alps, i.e., at altitudes between 800 m and 1400 meters above sea-level. The formation of so-called closed regions (bassins fermés) is promoted. It is not a condition that all potato growers produce seed (usually min. 80%) but that all use certified seed also for ware production. The conditions there, however, are not as favorable as, for example, those in Scotland or the Netherlands, thus necessitating a control of the harvested tubers for virus diseases before final certification.

Table 1. Development of seed potato production

	1945-51	1957-60	1964-67	1971-73
Renewal with certified seed as % of total potato/area	27	45	60	67
Swiss seed used as % of total certified seed requirement	35	55	82	ca. 95
Class A as % of total seed production (area)	15,7	64,4	90,1	96,0
Average virus %: Grade A (Swiss)	13,6	3,7	1,8	0,9
Grade B (Swiss)		8,8	5,3	3,3
Import all grades	3,1	3,4	0,3	0,4
National average yield metr. tons/ha	18,3	28,3	32,6	38,7

4. Seed potatoes used for multiplication

Switzerland has no clonal propagation; the risk is too high. From the total quantity of seed stocks necessary for the production of certified seed of the grades A (and B) during the years 1965-67 about 50% was imported as basic seed, mainly from the Netherlands, but during the years 1972-74 the total imported basic seed was only 20%. The rest, i.e. actually 80% was selected from Swiss grade A by means of field inspection and intensive testing in adequate combinations of A6-leaf test. Gomphrena test, serology, Igel-Lange test and autumn-field test (eye-cuttings). The unofficial grade of this selected seed is AS (A-selection) and such a lot can be the progeny of imported basic seed as well as of Swiss AS-seed. No lot which contains more than 2% total virus (maximum for virus Y = 1%), based on the investigation of at least 300 tubers, is designated as AS and thus admitted for further multiplication. Grade AS is not commercially handled, it is at the disposal of the Federation of Seed growers only for multiplication. Normally so many lots are tested for this purpose that not all AS-seed is used for multiplication but only the best lots with less than 0,6 to 0,8% virus. The surplus of AS is then commercially handled as normal class A. The experience with these selected lots is excellent (Table 1). In one year a large

quantity of seed suitable for the production of certified seed is obtained. By this rigid selection clonal propagation is largely replaced.

5. Conditions for certification

5.1 Field inspection

The certification of grades A and B based on two field inspections is only of temporary value; the final classification is dependent in any case on the result of the Igel-Lange test, the A6-leaf test or the field test in autumn.

The most important standards for field inspections are:

	Grade A	Grade B
	(maximum % plants at each visit)	
Leaf-roll and visible mosaic (secondary symptoms)	0,2	0,8
blackleg, wilt, missing hills due to roguing (details here not mentioned)	3,0	4,0

Fields for grade A must have a distance of at least 20 meters from any other potato field with a virus percentage of 1 to 10% or at least 50 meters if the virus percentage in the neighbour-field exceeds 10%.

Inspection of the growing crop is carried out by trained experts (Ingenieur-Agronom or experienced farmers). They start with the first inspection as early as possible, thus forcing the growers to early and efficient roguing. It is recommended not only to rogue out the diseased but also the neighbouring plants.

5.2 Haulm destruction

Based on Dutch and our own experience, haulm-pulling or haulm-killing at fixed dates was introduced in 1948. This was a very efficient remedy, and today regularly more than 90% of the seed potato area is treated that way. Haulm destruction is a necessary condition for certification in grade A. The dates for chemical haulm destruction are based on investigations of aphid development. From

about 130 sites in different regions of the country samples are collected and analyzed by specialists at the Agricultural Experimental Stations. Data are recorded in accordance with aphid development, altitude above sea-level and resistance and maturity of varieties.

5.3 Testing the seed tubers for virus diseases

Testing all seed lots for virus diseases before final certification (and commercialization) is an important step in the Swiss certification system. PVY-resistant varieties (grade A and B) usually are only tested in the ILT (Igel-Lange test), all other varieties in ILT and A6-leaf-test. Samples, taken by experts of the Federation of seed growers in the field according to a X-pattern contain normally 50 tubers, an additional sample of 200 tubers is taken in cases of probable rejection due to virus infections. For thorough testing of lots considered as AS see above.

The Agricultural Experimental Stations start with testing work in early August. It is possible to furnish all results by the end of October so that delivery of the seed to traders usually takes place before the first serious cold weather period.

6. Bulk inspection at delivery (sealing)

	max. % weight
Occurrence of soil and foreign substances	2
Mechanical damage, misshapen tubers	3
Common scab (severe symptoms)	5
Dry rot, late blight, powdery scab, Skin spot,etc.	0,5
Total limits for tolerances (without soil)	6
Soft rot, Frost damage	2 tubers per 100 Kg.

7. Efficiency test for the seed growers

The efficiency test is based on the results of the post harvest control-fields. At delivery, from each certified lot a sample

of 100 tubers is taken and planted under field conditions the next year. The purpose of this procedure is of course also to control the reliability of the testing methods. Virus percentage of each lot in the field test is compared with the Swiss average virus percentage of the respective variety and grade. After each period of a three-year's production a mean efficiency factor for every grower is calculated. This qualification may lead to the elimination of a grower from further seed potato production.

8. Economics of seed production

		Ostara		Bintje		Maritta	
		SFr.	$	SFr.	$	SFr.	$
Grower's price (prod.) 1974	consumption/q	28.-	9.30	41.-	13.60	34.-	12.30
" "	seed grade A/q	48.-	16.-	53.-	17.70	53.-	17.70
" "	seed grade B/q	39.-	13.-	45.-	15.-	38.-	12.70
Selling price	seed grade A/q	55.20	18.30	60.20	20.10	60.20	20.10
Cost for bulk inspection/q) all varieties				0,45	0,15		
Cost for testing/q) and grades				0,45	0,15		

9. Final remarks

Twenty five years ago, when Swiss seed, expressed in % of the total certified seed required, reached rarely 35%, there were considerable difficulties in selling Swiss seed potatoes. The farmers preferred imported seed of better quality. Introduction of more severe standards for certification, choice of the best sites for production and testing of the total crop before sale enabled improvement in seed production and to demonstrate that Swiss seed equals imported seed in cropping ability. Today there is no difficulties in meeting the total demand for certified seed. Switzerland exports more seed than it imports as part of their demand for basic seed.

WORLD REGIONS WHERE CIP IS INTERESTED IN SEED PRODUCTIONS

R. T. Wurster

As Dr. Sawyer said in his introductory remarks yesterday, CIP's mandate for potato improvement is directed to the developing countries of Latin America, Africa, the Middle East and, Asia. In the developing countries of these regions the lack of a supply of potato seed in sufficient quantities at a cost the country can afford is often the principal factor limiting the development of the potato as a food crop.

In this conference Mr. Paul Eastman, referred to natively produced seed potatoes as one of the principal natural resources of the state of Maine. This natural resource remains underdeveloped and unexploited in most of the countries CIP is trying to assist.

Although the countries of Europe and North America have played an important historic role in disseminating the potato to the countries of the developing world, developing countries can not fully advance the potato as a food crop until they have also developed a capability for potato seed production. I personally believe that those countries which are presently supplying the world market for seed potatoes, will find the demand for seed increasing, not decreasing, as developing countries increase their seed production capability. Furthermore, as the potato assumes a greater role, as a food crop in these countries, the demand for seed will probably increase faster than local seed supplies. Also as developing countries advance their capability to produce seed, their needs for elite or first quality seed will increase.

Because of the great importance of potato seed production to the development of the potato as a food crop in developing countries, CIP's Outreach Program has been charged with the responsibility

of assisting national potato programs to develop their seed production capability.

The world regions where CIP is interested in assisting seed production efforts correspond approximately to the seven regions of CIP's Outreach Program which are as follows:

Region I	-	South America
II	-	Central America, Mexico and the Caribbean Islands
III	-	Tropical Africa
IV	-	Middle East and North Africa
V	-	Non-Arab Moslem Countries
VI	-	India, Bangladesh and Nepal
VII	-	South-East Asia

CIP does not expect that each developing country will become self-sufficient in seed production. Potential of a country as a seed producer will depend on many factors which are the subject of this workshop. In some cases, one country in a region might become a regional leader in seed production and provide seed for neighboring countries. A possible example is Lebanon, with its high mountainous regions. Another example is Mexico, which is already providing some seed to its neighbors.

Some developing countries may have the potential to satisfy all their own seed needs, producing all classes of seed. For others with less favourable conditions seed production may consist simply of one or more multiplications of imported seed. An example is Panama which is multiplying imported potato seed from Holland and North America in their high elevation areas.

For all developing countries the full utilization of the potato as food crop will depend on the development of some type of seed production capability.

PRESENT SOURCES OF POTATO SEED IN DEVELOPING COUNTRIES

J.E. Bryan

A. Andean Countries of South America: (Bolivia, Colombia, Ecuador, Peru).

The principle species of these 4 countries is S. andigena. Both locally improved varieties and native varieties are grown. Hybrids of S. tuberosum x S. andigena are becoming, important.

Imported seed is less than 0.25% of total.

Seed programs are rudimentary at best.

B. Rest of the world.

1. Foreign varieties imported in previous years and being maintained with and without organized seed programs. For economic and other reasons, no seed is being imported at present.

   Examples are Costa Rica, Chile.

2. Using almost exclusively locally bred or selected varieties. Seed programs vary from semi-sophisticated to primitive.

   Examples are India and Guatemala.

3. Imports of foreign seed each year, mostly with one or more increases, but in some cases commercial plantings are made directly from the imported seed.

   Examples are Egypt, Pakistan will increase programs; Bangladesh and Panama with much seed planted directly to commercial fields.

4. Combinations - old imported and new locale varieties.

   Examples are Kenya and Mexico.

C. Seed Exporting Countries.

a) Major Importance

- Canada
- Denmark
- Germany
- Holland
- Northern Ireland

b) Minor Importance

- France
- Guatemala
- Mexico
- Scotland
- Sweden
- U.S.A.
- Communist Countries

POTENTIAL GENETIC LIMITATIONS OF NORTHERN LATITUDE SEED WITH RESPECT TO PHOTOPERIODIC AND OTHER PHYSIOLOGICAL RESPONSES

D. E. van der Zaag

Introduction

The response of varieties from northern latitudes to short daylength, high temperature, hight light intensity and drought and the importance of the dormant period of the seed will be discussed briefly. Finally some data will be given to indicate the potential yielding capacity of varieties from temperate zones in potato growing areas in tropical countries. Daylength, temperature and light intensity affect the growth type of a crop. In figure 1 growth type 1 is a crop with restricted haulm growth, early tuber initiation and early maturity and a crop with extensive haulm growth, late maturity is called growth type 2. In general type 1 will show a high tuber/haulm weight ratio and type 2 a low ratio.

The most important factors affecting the growth type of a crop are summarized in table 1. It is evident that there are interactions between these, e.g. high temperature has a different effect on the crop under short days and high light intensity than it has under long days and low light intensity. We must bear this in mind when discussing these factors separately.

Daylength

The main effect of daylength on the potato crop is on the tuber/haulm ratio and on the length of the growth period. Short days stimulate tuber initiation, tuber growth and maturity and restrict haulm growth, (growth type 1), while long days have the opposite effect (growth type 2). Kopetz and Steineck (1954) introduced the term critical daylength, above which no tuberization occurs. We prefer to define it as the daylength under which crop response changes from short day reaction to long day reaction.

Long day reaction means that tuber initiation is retarded and haulm growth is stimulated. In most varieties from northern countries that have been studied the critical daylength varies from 12-17 hours. From the work of Von Kittlitz (1963) and Bodlaender (1963) on the critical daylength of various European varieties, the following can be concluded:

Eersteling, Comtessa, Oberarnbacher Fruhe and Sirtema(early varieties).	15-17 hr.
Bintje (second early)	ca.15 hr.
Gineke (medium late)	15-17 hr.
Alpha and Ackersegen (late varieties)	13-14 hr.

In general the critical daylength of varieties that are late in northern countries, is shorter than that of early varieties. In the tropics and subtropics daylength varies from 10-14 hrs. With such a daylength and with moderate temperatures, crops grown from northern seed will make a shift to growth type 1 (fig. 1) or to a high tuber/haulm ratio. When there is a short growth period type 1 is superior to type 2, but if a long period is available, these short days will not induce a maximum yield.

Upadhya, Purohit and Sharda (1972) came to the conclusion that in India, where in some parts the same varieties should be grown in the hills under long day conditions and there after in the plains under short day conditions, neutral types are desirable.

It is evident that the total dry matter production per day is higher in a day with 15-17 hr. light than in a day with 12 hr. light, assuming that other factors are the same.

The short days restrict haulm growth. High temperatures however will stimulate it. As the daylength is short in the tropics, temperature may be higher there for optimal growth than in zones where daylength is long. In regions with high temperatures short days favour yield (see also Krug. 1960). Also Simmonds (1971) came to the conclusion that the main crop or late-main crop potatoes in the temperate zone do better at middle to low elevation in the tropics than at high elevations.

The photoperiodic response of most varieties belonging in northern countries to the medium or late maturity category, grown

in the tropics, favours rapid tuber growth and high yield, especially under warm conditions. Haulm development of early varieties may be too poor to produce maximum yield.

Temperature

Temperature may affect tuber/haulm ratio and net assimilation. The effect of temperature on the tuber/haulm ratio is in principal the same as that of daylength. High temperatures stimulate haulm growth and low temperatures stimulate tuber growth.

Recently Marinus and Bodlaender (1975) in Wageningen studied the tuber/haulm ratio of 8 varieties at three temperatures, under natural (long) daylength.

In tables 2 and 3 are shown the results obtained with 4 well known varieties. With all four, tuber yield and total yield are considerably decreased by high temperature. Eersteling, however, reacts much less strongly than Up-to-Date, both in tuber dry matter and in total dry matter production. Despite differences in varietal response all 8 varieties showed a strong decrease in production at high temperature. This is partly due to a shift to an unfavourable tuber/haulm ratio and to a decrease in net assimilation rate. Figure 2 shows that at 30°C (and high light intensity) the net assimilation rate of the variety Lemkes Planet is almost half that at 20°C.

A high temperature at day combined with a moderated night temperature is much less harmful than a high day and night temperature.

The unfavourable effect of high temperatures can be reduced by short days and high light intensity. High temperature can also stimulate second growth. Varietal differences exist.

Extremely high temperatures during a short period can damage the foliage, especially if water supply is not sufficient. All varieties are sensitive to these circumstances. Varietal differences exist, though not much data on this subject are available. We believe that some varieties from North America appear to have some more tolerance to such short periods of high temperature than European varieties (e.g. the new variety Nampa; see Pavek et al, 1973).

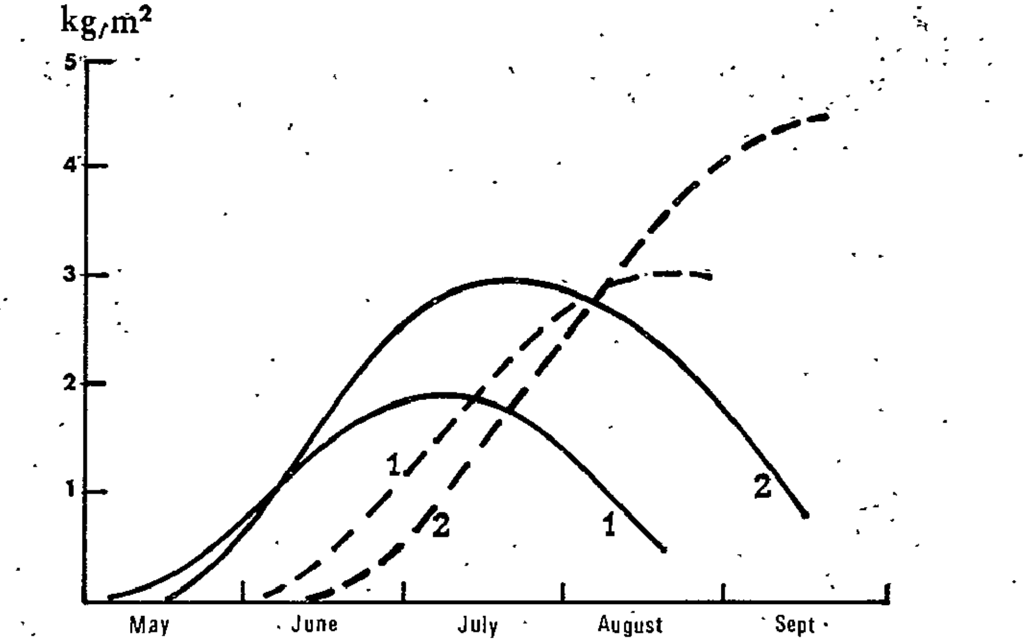

Fig. 1 Foliage (——) and tuber growth (– –) of early crops which produce comparatively little foliage which dies off early (1) and of somewhat later crops which produce a lot of foliage which continues to grow for a long time (2). Tuber growth begins early in Growth Type 1, but the yield is lower than in Grow Type 2.

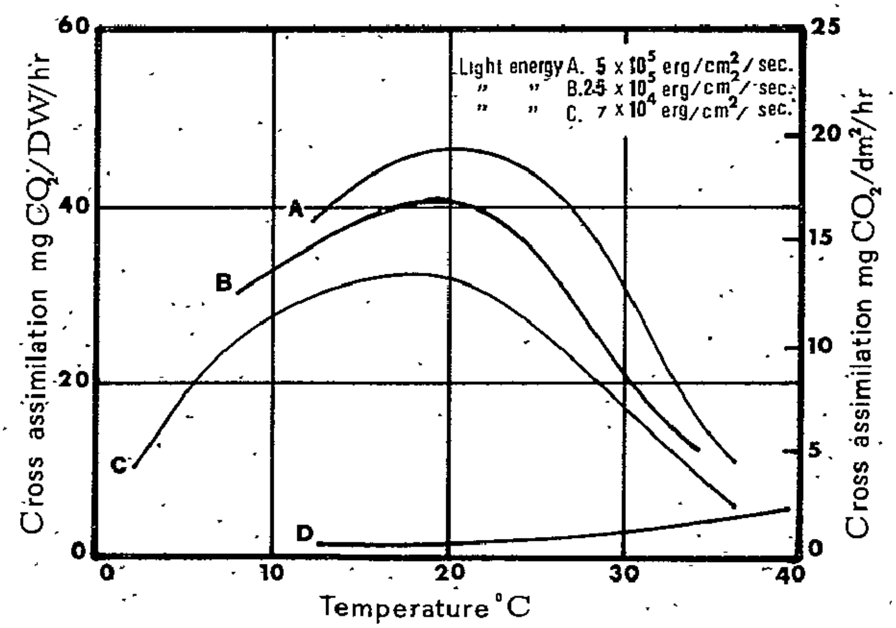

Fig. 2 Effect of temperature on assimilation and respiration (bottom line) for different light intensities of fully expanded potato leaves (figures compiled by Winkler, published in 'The Potato' by W. G. Burton).

The unfavourable response of potatoes to high temperature is a real limitation on its use in tropical and subtropical countries. It has been proved, however, in several countries where potato growing has been developed, that this limitation can be overcome to some extent by selecting the best varieties and the best season of the year and by providing an adequate water supply. Further more breeding programmes are now-a-days more and more directed towards providing heat tolerance, both in northern and southern countries, e.g. India (Upadhya and Singh, 1972).

Light intensity

Light intensity influences photosynthesis and also has some formative effects on the growth and development of the potato crop. The tuber/haulm ratio is decreased by low and increased by high light intensity.

High light intensity in the tropics favours photosynthesis and reduces the unfavourable effect of high temperature.

Not many data are available of varietal differences with respect to reaction on light intensity. In table 4 some unpublished data of Bodlaender, are given. The data show that at low light intensity varietal differences exist.

The strong radiation in the tropics is not a limiting factor in the use of varieties from northern latitudes.

Drought

Shortage of moisture can influence 1) the growth type of the crop; 2) rate of the photosynthesis; 3) the response of the crop to temperature. The effect of moisture supply on growth type is in general not great, but can nevertheless be used to regulate the growth type of a crop. More important is the effect on the carbondioxide concentration in the leaf tissue and so on the rate of assimilation.

In potato leaves transpiration is already reduced at a moisture stress of - 3 1/2 bar. (table 5, Rijtema, 1974). It may be assumed that photosynthesis is also reduced at this level. In warm dry climates potato production is only possible with frequent water supply. Varietal differences in yielding capacity under specific

moisture stresses are not available. As has been mentioned before, the unfavourable effect of high temperature is more pronounced under dry conditions. In practice it is known that some varieties are more tolerant of such conditions than others. Under high temperature conditions water supply following a period of drought leads in almost all varieties to second growth. It is assumed that varietal differences exist in this respect also, but reliable data are not available.

It is evident that all well known potato varieties are insufficiently tolerant to drought, when grown in dry climates without irrigation.

Length of the dormant period

The length of the dormant period is defined here as the period between harvest and the moment when sprout growth becomes visible under favourable conditions.

Emilsson (1949) found that of the 50 varieties he studied, the variety Eigenheimer had the shortest period (5 weeks: average of 3 years) and, of the better-known varieties, Arran Banner and Majestic had the longest (16 weeks: average of 3 years).

Without breaking dormancy artificially seed from northern countries should not be planted in the tropics or sub-tropics before the beginning of October, and then only in the case of varieties having a short dormant period from countries where seed is harvested at the end of July. Seed that is harvested at the end of August and which has a dormant period of 12 weeks, is not ready for planting before the middle of November. Well stored seed, with a long dormant period, carried in ships with refrigeration, can be planted until May-June. This means that from July to September no seed from northern latitude can be used and in October-November and in May-June only those varieties with short or long dormant periods respectively. By breaking dormancy with chemicals and to some extent by cutting the seed, the problem in September and October may be overcome. The other side of the problem is the length of the dormant period of the progeny of seed from northern countries. If these tubers have to be planted within 1 or 2 months, they should have a short dormant period, but if they have to be stored for a long time then a long dormant period is preferable. It is obvious that to meet all these requirements varieties with different lengths of dormant period must be available.

There is a wide range in the length of the dormant period in varieties from northern latitudes. None with an extremely short period, such as may be desirable in specific cases, e.g. India (Upadhya, Purohit and Sharda, 1972), are available.

Yielding capacity of seed from northern latitude

Discussion of the physiological responses of varieties from northern countries in isolation may give the impression that its yielding capacity is low in the tropics. Results of varietal trials (tables 6-8) with healthy seed from northern countries in regions between latitudes 30°N and 30°S indicate that varieties from temperate zones, grown with adapted techniques, can produce three times and more than the present average yields in these areas. The average yield of all countries between latitudes 30°N and 30°S was in 1966-70 7.5 tonnes per ha.

Conclusions

The response to daylength of varieties from northern latitudes is not in general, a limiting factor; short days even have a favourable effect under high temperature conditions. All well-known varieties are insufficient tolerant to high temperature and drought.

A limitation of seed from northern countries for use in the tropics and sub-tropics is that no seed can be supplied from June till September.

Despite these limitations seed from northern latitudes has the potential to improve yield in potato growing areas in the tropics and sub-tropics.

Table 1. Factors influencing growth type or tuber/haulm ratio

Growth type 1(high ratio)	Growth type 2(low ratio)
Varieties with restricted haulm growth - usually early varieties	Varieties with extenxive haulm growth - usually late varieties
Physiologically old seed and sprouts	Physiologically young seed and sprouts
Short days	Long Days
Low temperature	High temperature
High light intensity	Low light intensity
Low nitrogen	High nitrogen
Low soil moisture	High soil moisture

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Table 2. Tuber/haulm ratio (dry weight) of 4 varieties in 2 experiments (I and II) (Marinus and Bodlaender,1975)

T	Eersteling		Bintje		Alpha		Up to Date
	I	II	I	II	I	II	I
16°C	5.6	4.9	10.9	8.9	9.8	7.7	11.1
22°C	5.9	4.9	9.0	6.2	6.3	6.9	6.8
27/28°C	2.4	1.8	2.9	3.2	2.9	3.9	1.0

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Table 3. Tuber yield per plant (dry weight) and total dry weight per plant (in g) (derived from Marinus and Bodlaender,1975)

	Temperature					
	16°C		22°C		27°C	
	Tuber	Total	Tuber	Total	Tuber	Total
Eersteling	56	66	71	83	42	60
Bintje	87	97	82	91	41	59
Alpha	78	86	67	77	36	49
Up to Date	84	91	77	88	27	54

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Table 4. Varietal reaction on light intensity
Tuber fresh weight in grams per plant (average of 4 plants)
(Unpublished data from Bodlaender)

Light Intensity in Lux	Alpha	Irene	Bintje	Eersteling
16000	191	176	277	223
12000	194	151	231	191
8000	159	68	143	74
4500	58	30	109	73
1800	40	16	64	22

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Table 5. Moisture stresses in the leaves by which transpiration is reduced (data from Rijtema, 1974)

Crop	Moisture stress in bar
Cotton	- 13
Grasses (+ cereals)	- 10
Sunflower	- 7 1/2
Potatoes and pepper	- 3 1/2

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Table 6. Varietal trial near Dacca (Bangladesh) (planting date 2 December 1968)

Varieties	ton/ha
Eigenheimer	31.7
Humalda	31.0
Gineke	30.3
Multa	29.8
Bintje	29.1
Patrones	28.7

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Table 7. Varietal trial near Dakar (Senegal) (planting date 5 December 1973)

Varieties	ton/ha
Kerpondy	30.9
Spunta	30.7
Bintje	30.0
Mirka	29.8
Alpha	27.7
Desirée	26.6
Roseval	24.3

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Table 8. Varietal trials near Sao Paulo (Brazil) (planting date 2 February 1970)

Varieties	ton/ha
Mirka	38.0
Bintje	37.6
Vacuna	37.3
Emergo	36.3
Patawi	36.3
Spunta	36.1
Radosa	34.4

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BIOLOGICAL AND PHYSICAL LIMITATIONS OF NORTHERN LATITUDE SEED TECHNOLOGY FOR DEVELOPING COUNTRIES

INSECTS AND DISEASES AS LIMITING FACTORS

N.S. Wright

The record shows that the potato had its origin in the Peruvian and Bolivian Andes, was introduced into Europe about the middle of the 16th century and spread from there to North America and the other continents. Historians say that the earliest types of potato grown in western Europe were typical of the Andigena group. New varieties were raised from true seed and selection under the moist, temperate, long day, long season conditions of Europe led to the use of cultivars with characteristics of the Tuberosum group. They were well adapted and current figures show that over 90 per cent of the world's potato production is in the north temperate zone, mainly in eastern Europe and U.S.S.R.

It is well known that climatic conditions, day length, soil type, cultural treatment as well as the incidence of pests and diseases influence the yield of potatoes. In this paper we are concerned with the last two and specifically with examples of these which have required the development and application of seed improvement technology. We are not concerned on this occasion with factors which influence yield, grade and quality of potatoes for uses other than seed.

One of the first facts to be accepted was that the potatoes introduced into Europe in the 16th century contained a wealth of diverse genetic material. Re-combinations of the genes gave a wide range of contrasting morphological features and physiological responses. Variability included differences in photoperiodic reaction, potential yield, and disease resistance. The characteristics of any individual member of such an inherently variable species could only be retained by vegetative propagation. This practice also assures the perpetuation of systemic pathogens. Long before viruses were recognized and the role of bacteria and fungi in disease was understood it was shown that varieties which

had lost vigor and cropping capacity retained the potential for productivity. This fact was utilized in potato breeding programs. It was at the beginning of the present century that the first knowledge of viruses was recorded and in relatively quick succession came detailed information about virus transmission, about the etiology of other viruses, bacteria and fungi and more recently about mycoplasma and viroids. Based on an understanding of the relationship between the potato and its pathogens it was possible for potato improvement programs to concentrate on disease control. Seed potato certification schemes developed. In recent years the main impetus for potato breeding has come, not from the necessity to replace degenerated varieties but from the desire to introduce resistance to diseases and for special quality improvement.

Field inspections, roguing, winter testing and tuber or plant indexing are standard techniques which have enabled effective control of several diseases and plant aberrations. Special technology is required to control pathogens which are transmitted by insects from inoculum sources outside seed potato fields and those which do not always cause diagnostic symptoms on potato. Pathogens which are challenging the resourcefulness of growers, researchers and seed improvement agencies in North America at the present time are potato leaf roll virus (PLRV), potato virus X (PVX), potato virus S (PVS), potato spindle tuber viroid (PSTV) and the potato black leg bacterium, *Erwinia carotovora* var. *atroseptica*. A review of these will illustrate how insects and diseases may limit the success of seed improvement technology in any country.

Potato Leaf Roll

Any consideration of technology regarding control of PLRV must take into account the life history of the principal vector, the green peach aphid, *Myzus persicae*. This insect overwinters either as eggs on certain *Prunus* spp. or as viviparous female nymphs on sugar beet, cabbage, kale and numerous other crop and weed plants which are protected from destruction by adverse weather. In early spring apterous females hatch from the eggs and these produce more apterous females asexually. The next generation, also produced asexually, consists of alates capable of flying to summer hosts such as potatoes, brassicas, etc. In mild regions, particularly near urban areas where truck crops are grown commonly, the aphids from these may form a major part of the population which flies to the summer hosts. Flights

during the summer occur when alate individuals are produced in response to conditions which prevail in crowded colonies and when the weather is right for voluntary flights. The distance travelled is influenced greatly by wind velocity and air humidity. Possibly the longest record of wind dispersal is 1300 kilometers. In the autumn apterous females produce a generation of winged females and later a generation of winged males. The winged females migrate to peach trees and other winter hosts where they produce, asexually, a generation of apterous oviparous females. After being fertilized by the winged males the females lay the over-wintering eggs, usually among the leaf scars at the bases of the youngest shoots.

Aphids arrive in potato fields during the spring migration from winter hosts. These aphids are free of virus but those which land on leaf roll infected plants acquire PLRV upon feeding and become viruliferous within 24 hours. During subsequent short flights they may spread the virus to other plants within the field or to an adjacent field. Some aphids of the summer flight will have developed on PLRV infected plants and these may spread the virus to plants many kilometers away.

The technology utilized in the control of PLRV stems from the research effort applied by laboratories throughout the world. The virus has been purified and hope exists that a serological test may be possible. Biological control of aphids by aphicidal fungi is also showing promise. It is known that mild strains of PLRV may be symptomless on potato. Confidence that tubers to be utilized at the first level of increase in a clonal increase program are free of all strains of PLRV relies on tests on the susceptible species _Physalis floridana_. The correlation between the number of aphids caught in water traps and the extent of PLRV spread must be done on an area or district basis. For some the correlation may show that foliage removal by a given date may avoid inoculation. Each seed improvement agency is obliged to ascertain which strategies are needed to control PLRV.

Potato Virus X

PVX is not transmitted by aphids; sap transmission by direct contact between infected and healthy sprouts, leaves or roots or indirectly by contaminated machinery, clothing and animals (including chewing insects) accounts for a steady increase in stocks which contain even a trace of infection. In Canada and U.S.A. most fields of older varieties such as Russet Burbank, Green

Mountain and White Rose are still 100 per cent infected. Most official seed farms and a few foundation seed growers have stocks from which PVX was removed by heat therapy and meristem culture since 1967 and these are gradually replacing the infected stocks in some areas.

Technologically, PVX is easy to diagnose and control. Good antisera are easily made but perhaps the greatest aid to PVX control is the local lesion host, Gomphrena globosa. Inoculum from composite samples consisting of leaf tissue from one infected and 49 healthy plants will usually cause several local lesions on this excellent test plant. Because of the highly infectious nature of PVX the key to successful control is the use of virus-free material particularly at the early stages of the tuber line or family increase program. Once all of the potatoes on a farm are PVX-free careful seed growers appear to have no difficulty avoiding contamination.

Potato Virus S

PVS, like PVX, is widespread in the seed stocks of Canada and U.S.A. Seed farms and Foundation Seed growers have had less success with PVS control than with PVX control. PVS-free stocks are available but, possibly because of the lack of a test plant which is as sensitive to PVS as G. globosa is to PVX, control of this virus is failing in North America. Good antisera are available. Possibly the incentive to control PVS is lacking because infection with the common strains seems to cause little, if any, economic loss.

Potato Spindle Tuber

PSTV has not become widespread in seed potato stocks possibly because even the mild strains of this viroid usually cause diagnostic tuber symptoms. The fact that infectious nucleic acid (viroid) occurs in pollen and true seeds from infected plants emphasizes the need for assurance that potato breeding programs utilize plants which are free of PSTV. The Rutgers variety in tomato is the best available test plant. It shows good symptoms of severe strains and by utilizing cross-protection, a fairly reliable test for mild strains is possible. One cause of error is the loss of infectivity in freshly-extracted plant sap thus making the results of sap inoc-

ulation somewhat inconsistent. Furthermore, a period of three to six weeks is required to obtain test results. A test for the specific nucleic acid on polyacrylamide gel shows promise as a fast (3 days) and reliable test for mild and severe strains.

Potato Black Leg

Recent research is showing that the cause of Black Leg, *Erwinia carotovora*, var. *atroseptica* is commonly carried from year to year in seed tubers and that survival in soil is of minor, if any, significance in the etiology of this disease. The incidence of the disease is reduced by utilizing stem cuttings in the propagative process but recontamination is common. Sources of contamination are farm equipment, plant and tuber debris in storage. Potatoes which remain in fields over winter and are protected from destruction by adverse weather will perpetuate the bacteria. Insects, especially fruit flies, are capable of disseminating the bacteria from infected to healthy plants.

PLANNING SEED PRODUCTION PROGRAMME TO FIT CLIMATIC ZONES

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Inter-action of altitude and latitude provides cool climate in one season or the other, enabling potato cultivation in the tropical zones of India. Distinct areas of seed production in hills and plains, cultural practices and channels of seed movement developed traditionally, based on dormancy and storage problems, rather than consideration of diseases.

Studies on dynamics of *Myzus persicae* population confirmed the suitability of high hills but revealed the weakness of traditional systems in the plains, where seed crops were raised in late winter or spring when *M. persicae* had high infestations. "Seed plot technique" was developed for raising seed crops during the aphid-free period in the northern plains by planting in October and removing haulms by December before aphids attain critical number (20 per 100 leaves). Seed stocks thus, raised compared favourably with that from temperate high hills reducing incidence of leaf-roll and Y to 0.2%. Data on aphid population are collected from 15 important potato growing regions for demarcating suitable areas and safe periods for raising different classes of seed and for maintaining health standards through use of systemic insecticides in certain areas.

Different conditions of day-length under which crop is grown in different seasons emphasize the importance of day-neutral varieties of long dormancy and better storability will continue to be important. Such varieties should, however, respond to dormancy-breaking treatment to utilize the freshly harvested (dormant) seed tubers from high hills for planting in the plains and vice-versa to speed up seed multiplication rate. Agronomic methods are also being employed to increase the yield of seed size tubers.

PLANNING SEED PRODUCTION TO FIT CLIMATIC ZONES; BREEDING TO OVERCOME DORMANCY AND INFLUENCE OF EXTREMES IN ALTITUDES, AND RANGE OF LATITUDES

L.C. Sikka and Mukhtar Singh

In the northern latitudes, the potato is grown under long-day conditions in summer and the produce is generally stored over through the winter when low temperature prevails. The practice of change of seed from relatively northern to southern latitudes developed as a result of the experience of farmers that the seed from the north gave rise to vigorous crop with high-yielding capacity. This, in due course, was explicable in terms of low-aphid incidence and freedom from viruses of seed from northern locations. Subsequently organized systems of seed production and certification developed to identify quality stocks from reliable sources. The basic concept in all the schemes had been to develop stocks with high degree of genetic purity and freedom from seed-borne diseases. For example, in Scotland, initially the certification scheme was initiated in 1918 to control wart (Synchytrium endobioticum) by making available reliable wart-immune stocks; from 1932 emphasis was placed on control of leaf-roll and severe mosaic; from 1950 mild mosaic and latent viral diseases were also brought into picture and virus-tested seed (V.T.S.) was introduced; from 1968 seed-borne, fungal and bacterial diseases as well as cyst-forming nematode were also taken into consideration leading to the introduction of virus-tested stem cutting clones and stocks (V.T.S.C.).

Most of the developing countries are located in the tropical and sub-tropical zones. A part of crop is grown in summer at the higher altitudes. For example in India, the modifying effect of altitude on temperatures results in a crop season akin to temperate regions in the Northern Himalayan hills above 2,500 m. Under such conditions, seed technology developed in the northern latitudes could be utilized with suitable adjustments. However, large areas in the developing countries are cultivated in winter under short-day conditions and the produce is stored during summer months. In fact about 90 per cent of the potato culture is in the sub-tropical and tropical regions and the crop is grown under the conditions vastly different

than the northern latitudes imposing serious biological and physical limitations on the application of northern latitude seed technology.

Climatic zones.

Although India like other developing countries is located in tropical and sub-tropical zones, interaction of altitude and latitude produces distinct seasons of cool climate which permit potato cultivation in almost any part of the country. The crop is grown under long-day conditions during summer at higher altitude in the Himalayan hills (above 2500 m); there is a spring as well as an autumn crop in the mid hills (1000-2000 m); an early or autumn crop and spring crop in succession in the North-western plains where winter are long and intense (below 300 m); a main crop (autumn) in the north-central and north-eastern plains characterized by mild winters of short duration; and in the rainy season and winter (rabi crop) in the tropical plateau region where growing periods are short because of high temperatures. Because of the effect of latitude, the extremes of temperature do not prevail in the Southern tropical hills despite its altitude (1000-2000 m.). Three crops are grown there, viz., the summer and the autumn crops in succession and the winter crop - where facilities for supplementary irrigation exist. The crop in the northern temperate hills is mostly rainfed, while it receives supplementary irrigation in the mid-hills as well as in the low lands (the rainy-season crop) and is frequently irrigated (12-14 irrigation) in the sub-tropical plains as well as in low lands (rabi crop).

Considerable variations are also found with regard to disease development in different ecological regions. Late blight (Phytophthora infestans) is more or less confined to the high hills, southern hills, and the north-eastern coastal plains with warm and humid climate. It also occasional occurs in the mild winter or the north-central plains. Bacterial wilt (Pseudomonas solanacearum), Root-knot nematodes (Meloidogyne spp.) and Tuber-moth (Gnorimaschema operculella) are wide-spread in the mid-hills, southern hills, north eastern hills as well as eastern coastal plains and plateau areas. Bacterial wilt is a pathogen favoured by warmer and humid climate. Wart has only been reported from the Darjeeling area in the north-eastern hills while the dangerous cyst-forming nematode (Heterodera rostochiensis) is localized in the southern hills. The high temperate hills being wind swept and well-exposed, have a rare incidence of aphids. On the other hand, M. persicae is widely reported from all other locations during certain periods of the crop season and the crop suffers in varying degrees from the degenerative

effect. The less important pathogens which include black-scurf (Rhizoctonia solani), Common scab (Streptomyces spp.) and Charcoal rot (Macrophomina phaseoli) tend to be confined to plains and epilachna (Epilachna ocellata) in the hills. Lately, mycoplasmal-associated diseases viz., purple-top roll, marginal flavescence, hairy sprout and witche's broom have also been observed in the hills and the plateau areas.

Traditional centres of seed production and channels of seed movements.

As a result of the stoppage of seed importation during the World War II, distinct areas of seed production, cultural practices and seed movements in the hills and plains developed. The seed of 'Darjeeling Red Round', and indigenous variety obtained from Darjeeling, Nepal and Shan hills (Burma) was invariably cut and utilized in late planting for raising the seed crop. Once grown or twice grown seed raised in the north-central plains (secondary centres) was either used locally for ware production or supplied to other ware-producing areas in the country. This pattern was for the varieties which responded to both short-day sub-tropical and long-day temperate environments or the varieties which were produced for seed purpose only in the hills. A second pattern involved raising seed crops in the plains as a late crop in respect the varieties e.g., 'Phulwa' and its variant 'Satha' (Andigena types) which were essentially short-day adapted varieties. These varieties had long dormancy, and were late in maturity and produced large number of small-sized tubers. Tubers of such varieties kept well as compared to varieties inherently producing a few but large-sized tubers under rigorous conditions of temperature and humidity without recourse to refrigeration which was not common during those days. These varieties being late in maturity, were adversely affected by charcoal rot towards the maturation phase when high temperatures resulted in significant rot both in the field and later during storage. Late planting for raising seed crop was adopted to minimize the storage period so that seed was not over-sprouted by the time it was ready for early or main plantings in the plains. The method of storage consisted in keeping tubers in cool mud-houses with thatched roofs on the floor under sand as a protection against tuber-moth and shrinkage during summer months from April to June and placing them into baskets in the rainy season. The tubers were examined periodically for resprouting and removal of rotted ones. The main emphasis was on storage and dormancy problems rather than health, with the ultimate aim to deliver

the seed stocks in the right physiological condition at the time of planting. The relatively mild and humid climate of the north-central plains during the storage period and the development of improvised method of storage of seed potatoes contributed to sustaining the potato industry. This system despite its defects had one major advantage: the seed stocks were free from the leaf-roll virus as it was inactivated in the improvised country stores (Thirumalachar 1954). However, the presence of other viruses could not be ruled out.

Planning scientific seed production.

Selection of suitable localities and growing periods based on studies on the appearance and build up of aphids as well as on the incidence of tuber and soil-borne diseases are the pre-requisites from the point of view of growing healthy seed material. These studies confirmed the suitability of high temperate hills for production of quality seed (Vasudeva and Azad, 1952). The seed crop in the high hills is planted during April and is allowed to grow up to the end of August when the haulms are killed to prevent any possible tuber infection due to late blight in the susceptible varieties and virus infilteration due to appearance of aphids. Such areas however are limited and the cost of production is also relatively high thus making it limiting for a large scale seed production programmed. This stimulated research to develop the technology for commercial-scale seed production in the plains where the major potato cultivation is concentrated.

Extension of the studies on the dynamics of aphid populations have revealed that *M.persicae* is practically absent from October to December in the main-crop season in the northern plains. High quality seed comparable to that of the hills can be raised during this period by the adjustment of planting and lifting dates and plant protection management. Consequently a seed production technology to exploit the vector-free periods in the northern plains was evolved (Pushkarnath 1967; Nagaich *et al* 1968; Pushkarnath *et al*, 1971). The technique consists of planting the seed crop during the vector-free period in the northern plains; killing the haulms towards the end of December as soon as aphids attains the critical number i.e. 20 aphids per 100 compound leaves; preventing of the regrowth; and allowing 10-15 days' time before harvesting so that the skin of the tubers mature. The studies undertaken to compare the health standards of the low-aphid seed produced in the northern plains with that of high hills have established that the incidence

of insect-transmitted viruses Y, A and leaf-roll is not more than 0.2 per cent and that of contact viruses X and S not more than 1.1 per cent i.e. well within the prescribed limits of tolerance for production of basic seed (Table 1).

Table 1. <u>Incidence of virus diseases on crops raised at Jullundur (sub-tropics) and Kufri (high hills)</u>

Variety	Sub-tropics Jullundur			High hills (Kufri)		
	No. of plants tested	No. infected with: Contact viruses X & S	Severe mosaic virus Y and leaf-roll	No. of plants tested	Contact viruses X & S	Severe mosaic virus Y and leaf-roll
Up-to-date	172	2	1	75	2	0
Great Scot	107	2	1	213	2	1
Graings Defiance	18	1	0	128	2	0
Others	253	1	0	235	0	0
Total percentage infection.	100.0	1.1	0.4	100.0	0.9	0.2

Further studies at Jullundur station (plains) of the Institute showed that rate of annual degeneration in the large bulk plots during the low-aphid period for three to four successive generations was of the order of 1.2 per cent (Table 2). The incidence of marginal flavescence and purple top roll was also negligible than in the hills.

Table 2. Average virus infection (percentage) over 3-4 generations in the plains during low-aphid period.

Period of successive culture (years)	No. of cultures observed	Leaf roll	Severe Mosaic	Mild Mosaic	Total	Annual rate of infection
4	7	2.3	3.0	0.1	5.4	1.3
3	8	0.7	1.8	0.2	2.7	1.0

Low-aphid seed stocks developed in the northern plains not only ensure freedom from diseases but offer the following distinct advantages:

(i) Low-aphid seed, because of its better sprout development capacity and good physical condition at the time of planting after seven months of storage, was found to result in quick plant emergence with multiple stems and better final plant stand than traditionally once-grown hill seed in the spring crop (Sikka 1974). The high density of stems per unit area is favoured in the seed crop. Tuber development was also rapid and the final tuber yield was high (Table 3 and 4).

Table 3. Rate index and plant emergence (per cent)

Variety	Once-grown hill seed Spring		Jullundur Station Low-aphid seed	
	Rate Index	Percentage plant emergence (30 days after planting	Rate Index	Percentage plant emergence (30 days after planting
Up-to-Date	0.83	40	0.93	67
Kufri Red	0.84	38	0.92	63

Table 4. Bulking rate in low-aphid seed expressed in percentage of the once-grown hill seed (spring) in the northern plains.

Variety	Days after planting					
	60	70	80	90	100	110
Up-to-Date	117.3	57.1	10.8	31.0	14.2	26.4
Kufri Red	265.8	114.9	151.3	73.3	115.0	109.1

(ii) Crops resulting from low-aphid seed exhibited high responses to fertilization (Table 5) as compared to once-grown hill seed (Sikka, 1974).

Table 5. Average yield (q/ha.) as affected by the source of seed and fertilizer.

Source of Seed	No Manure	N 100 +P 50 +K 100	N 200 +P 100 +K 200	Average
Up-to-Date				
Spring Seed	106.4	221.0	281.7	203.4
Low-aphid Seed	135.1 (27.0)	308.9 (39.8)	396.7 (40.8)	280.3 (37.8)
Kufri Red				
Spring Seed	130.3	227.5	272.6	210.6
Low-aphid Seed	125.0 (-4.1)	298.7 (31.3)	361.9 (32.7)	262.4 (24.6)

Figures in parenthesis indicate percentage increase/decrease over spring seed.

(iii) Most of the tuber and soil-borne diseases found in high hills did not persist in the plains because of the hot summer, hence better health standards are assured.

(iv) The rate of multiplication in the low-aphid crop was high as the crop is irrigated and also because of bright weather and low temperatures during tuberisation. The crop is not subject to late blight which is a limiting factor in the hills, hence cost of production of low-aphid seed is comparatively lower.

Recently systemic insecticides for controlling vectors of viruses have also been used in seed potato production with a reasonable amount of success (Patkar, et al, 1969). Periodic application of chemicals for the control of aphid vector considerably reduced the insect-transmitted viruses (Table 6). This has opened up new possibilities of growing potato seed of reasonable health standards in areas like plateau and eastern coastal plains which otherwise are not technologically suited for seed production. However, in such areas due to the incidence of bacterial wilt, the seed crop would be taken only in the fields where no potatoes have been grown in the preceding two years. This would eliminate the necessity of replenishing seed every year from the northern regions and thus cut down on the cost of production.

Table 6. Chemical control of aphids.

Treatment	Average Percentage PLRV	PVY	Total
Oxydementon methyl	1.25	2.49	3.74
Dimenthoate	2.04	3.40	5.44
Thiomenton	2.64	3.65	6.29
Methyl parathion (non-systemic)	1.91	3.59	5.50
Control	7.90	15.89	23.79

Breeding varieties suited to specific requirements in different climatic zones.

Development of the fore-going seed production systems for varying cultural requirements under which the crop is grown, has imposed specific varietal requirements. The new technique of seed production in the northern plains envisages that haulms of the seed crop are killed by the end of December when the number of aphids approaches a critical threshold. It, therefore, implies pre-mature lifting. As a result, potato yields are greatly reduced. Therefore, an important attribute of the varieties to be included in the seed production programme should be their inherent capacity to build up abundantly in a short time so as to give optimal yields. Further the seed potatoes thus produced have to be stored for 7-8 months as against storage period of 4-5 months in the traditional seed crop raised during the spring crop from hill seed. Long storage adversely affects the physiological condition of the seed tubers as the seed becomes senile. Therefore, varieties having long dormancy rather than having short dormancy are ideally suited. Such varieties should also be highly responsive to dormancy breaking chemicals. It would enable the effective utilization of freshly harvested seed tubers for immediate planting (Patkar et al, 1973). Most of the newly evolved varieties meet these requirements. These varieties should have the inherent capacity to resist virus infection in the field. However, if such varieties become infected they should be sensitive enough to show symptoms.

Different conditions of day-length under which the crop is grown in different seasons in the tropical and sub-tropical regions of India, emphasize the importance of varieties with day-neutral reaction. Such varieties because of high photo-synthetic efficiency are expected to give satisfactory performance both in the seed growing areas and in the areas where the seed is consumed. For example in the plateau and eastern coastal regions the foundation material to feed the seed production programme is to be linked with cooler regions in the high temperate hills or northern India.

Another important consideration influencing potato breeding in recent years is the desirable agronomic characteristics of the high yielding varieties. Such varieties should produce a large proportion of seed-sized tubers. Although this component is genetically controlled, it can be greatly modified by adoption of suitable agronomic practices. The relevant studies undertaken at the

Institute (Table 7) have shown that the varieties which inherently produced 5-7 tubers per plant, could be made to produce 15-25 tubers of medium-sized tubers per plant by use of large seed with multiple sprouts and the adjustment of inter-and intra-row spacings (Sikka, 1974).

Table 7. Studies on seed-size-cum-spacing in different varieties (Mean of 20 plants).

Variety	Spacing at 60 x 30 cm. No. of stems	No. of tubers	Total weight (gm)	Spacing at 90 x 90 cm. No. of stems	No. of tubers	Total weight (gm)
Kufri Chandramukhi	5.3	10.4	269.5	7.9	18.3	1,017.5
Kufri Sindhuri	6.2	10.4	345.7	6.9	32.8	740.7
Kufri Alankar	4.8	7.8	331.7	6.8	14.9	1,510.0
Kufri Sheetman	7.6	15.8	538.5	9.4	26.7	1,115.6
C. 990	6.2	15.8	454.0	6.9	19.5	1,252.7

Seed weight used for the studies: above 100 gm.

Agronomic advances - The spread of mechanically transmitted viruses 'X' and 'S' could be minimized in the seed crop by dispensing with post-emergence field operations. Studies on this aspect have suggested that the seed crop earthed up immediately after planting followed by pre-emergence application of herbicides reduced the incidence of contact viruses without detrimental effect on the yield (Mukhatar Singh et al, 1972).

Seed treatment with a mercuric compound coupled with hot-weather treatment in summer months in the plains proved effective in minimizing the spread of black-scurf (Sikka et al, 1971).

The technique of breaking dormancy and adoption of agronomic practices such as use of mulching and shade has made it possible to

utilize the freshly harvested seed tubers from the high temperate hills and vice-versa. The rate of multiplication can be enhanced to 25 times in a year. There is considerable time-lag between the release of new varieties and their exploitation. This method offers great promise to speed up multiplication (Ramanujam <u>et al</u>, 1957).

<u>Development of nucleus seed material</u> - One major single factor for sound seed production programme is to start with initial basic seed material as it determines the health standards of subsequent grades of seed potatoes. Under the scheme for production of breeder's stocks of potatoes, nucleus seed of improved varieties is developed in a phased programme consisting of four stages starting with indexing. In this way, about 1500 metric tonnes of breeder's seed are produced annually which filters down in the seed production programme. Thus, a vital link is provided in the spread of new varieties and maintenance of the health standards of different grades of seed potatoes.

Against the above back-ground, it may be safely assumed that since the climatic and growing conditions in several of the developing countries are more or less comparable, the seed technology developed to suit the specific cultural requirements in different ecological regions of India can be applied of course with suitable modifications. A two-fold approach is also suggested to rapidly produce healthy seed potatoes in the shortest possible span of time. The first is to start with high quality seed through an organized seed production programme. This system aims at major break-throughs by stream-lining the procedures for production of healthy seed potato in the cooler areas in the plains under short-day conditions during winter months. This would go a long way in popularizing potato cultivation through the use of home-grown seed potatoes at a comparatively much cheaper cost. The second approach would be to start at the other rung of the ladder and organize programmes of roguing of growers' fields in seed producing areas thereby improving the health standards of existing stocks. Both these lines of work may, it is felt, be adopted simultaneously and in fact could possibly supplement each other in progressively raising the health standards of seed potatoes.

As the seed potatoes are to be stored during summer months, adequate storage facilities are required to be built-up to ensure proper physiological condition of the seed material at the optimum time of planting as also to reduce losses in storage. Besides,

more research work is needed to standardize storage requirements of the seed potatoes under tropical conditions.

Greater exchange of research information on seed production and its post-harvest technology could be useful.

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PRESENT PROBLEMS WITH IMPORTED SEED

Said A. El Baz

Dear Colleagues:

It is great pleasure to have the opportunity to attend this conference. Furthermore it makes me glad to meet the CIP staff and all the participants at this conference. This meeting is considered one of the very successful CIP's - activities for the promotion and developing the potato crop in many regions of the world. I would like to say that, although the CIP has been recently established in the Middle East and North Africa (just a few months), yet we have felt in Egypt and in the Arabic Countries the great activity, sincere help, and the fruitful cooperation of all the CIP's staff in developing the potato programs in this region. The first Regional Workshop-Seminar on Potato Seed Production and Storage in Arab Countries held in Cairo, Egypt in May 1974 was one of the successful activities of the CIP-Region IV in the Middle East.

Dear Colleagues:

Potato is becoming more important as a universal food, particularly in the developing countries. The expanding of its cultivation is extremely urgent to satisfy the needs of the continuously increasing population. Furthermore, it could be an economic substitute for other staple crops especially cereals which have shown sudden increases in price.

It is well known that the yield of potato tubers per unit area exceeds that of other staple crops. Consequently, potatoes can contribute much toward solving the problems of shortage of world food especially in developing countries.

Before dealing with the subject, I would like to mention briefly two important facts related to the topic, viz. the situation of potato seed production in the developed countries

with respect to the acreage and production, and that of some seed importing developing countries. It is quite clear from (Appendix I) that the acreage and production of seed potato in the main producing countries are merely constant or even showing a slight decrease particularly in the U.S.A. and Europe. On the other hand there is a steady increase in potato acreage and seed requirements in the developing countries that import their needs from developed countries. As an example, the situation of the seed importing countries can be clearly shown with Arab countries.

The annual cultivated acreage, (Appendix II) in Arab countries has increased from 65000 ha., during the period 1948-1952, up to 133000 ha. in 1972.

Countries of the Middle East and North Africa depend entirely on Northern Europe for their annual requirements of seed Potatoes for the spring planting seasons.

This situation has created several problems and difficulties for the seed importing countries in the region. The problems with imported seed to this region can be summarized as follows:

I. <u>The choice of suitable varieties</u>:

Varieties used in this region are bred and produced under northern European environmental conditions which are certainly different from those of the M.E., and N. African. Consequently, the behaviour and productivity of these varieties would be different. This has been reflected as decreased yield when grown under the higher temperature and shorter days of the new environmental as compared to the conditions where the original selection was made. Perhaps even more serious is the situation where some developing countries import seed for production without first conducting varietal trials. In Egypt however, we do have a program presently of testing potential seed sources.

In countries that follow the varietal evaluation, the seed of the promising new imported varieties are not always available, the cost becomes prohibitive in importing large quantities. This situation would prevent developing countries from large scale introduction of promising high yielding varieties.

Consequently they continue to depend on the lower yielding traditional cultivars and no progress in production can be expected.

As for the countries that do not follow a varietal testing research program, they are obliged to import any available varieties and classes that may be low yielding, and unknown for both the growers and consumers.

2. Seed Prices:

Seed potato prices have shown increases during the last few years. For example, the price of Irish Arran-Banner seed imported by Syria was 23, 46.5, 64.7 and 97.1 for 1962, 1969, 1973 and 1974 seasons respectively. The prices of the Dutch Alpha seed imported by Egypt were 31.00, 44.00, 47.00 and 73.00 L.P. in 1962, 1967, 1971, and 1974 seasons respectively. The respective figures for the Irish King Edward were 30.6, 37, 40, and 65 L.F. Thus it is clear that the prices show 2 or 3 fold increase in the last two years. This sudden and extremely abnormal increase in seed prices may be attributed to interfering and complicated factors such as: of seed potato acreage in the producing countries, the increased demand of seed for satisfying the expanded acreage in the developing importing countries, the increase in cost of living and labour all over the world, and the higher cost of transport. We believe that these factors would lead to further increases in prices in the future. This situation would result in the following problems:

Potato production would not be profitable with higher seed prices in the region and many growers are considering changing to more profitable crops. Consequently the total production will not satisfy the needs of local markets and there will be even a shortage in the exported quantities for the foreign market. Thus, this situation would result in hazards to both seed producing and consuming (importing) countries.

3. Political problems:

The political situation between the seed producing and consuming countries can affect the availability of seed potatoes to a region if they continue to depend entirely on the foreign countries for satisfying their seed needs. A good example of this occurred during the World War II, and in 1956 when the Mediterranean Sea and the Suez Canal were closed and no potato seed were available and potato production was almost discontinued. In 1967 and the 1973 M. East wars, it is quite certain that if these wars had to be continued for longer periods, it would have been impossible to import any quantity of seed to this region.

4. Disease problems:

The continuous importation of seed potatoes can be a good channel for introducing some serious diseases of potato which do not exist in the importing countries. This problem is a result of the improper implementation or absence of quarantine regulations of the seed importing countries. Large amounts of high quality seed were rejected from some European countries due to the infection with some diseases which do not exist in the region. The following diseases and pests are not found in M. East and could be introduced:

Root knot nematode, colorado beetle, Corky ring spot virus, Potato spindle tuber virus and Ring rot bacteria.

5. Physiological disorders:

Seed consignments can be subject to some physiological diseases and disorders during harvesting, handling and loading in the seed producing countries. Super cooling (chilling injury) is one of the more serious physiological diseases which causes seed pieces to decay and the failure of seed to germinate. This manifestation of low temperature injury has a harmful effect on the meristematic tissues of the buds and often causes its death. It is very difficult to identify this type of low temperature injury by the quarantine inspectors even after cutting because the tubers look sound and healthy and are apparently free from internal symptoms. This problem has frequently happened in Egypt with some European grown seed which has caused serious losses to the growers.

Delays in shipment or inadequate ventilation can result in deterioration of the physiological quality of the seed due to very high losses of both decay and excessive sprouting. More than 30% of the seed imported by Sudan last year was completely rotten and was discarded due to the very long period of a shipment and problems in internal transportation.

6. Late arrival of imported seed:

In most cases it is very difficult to get the imported seed in the most suitable period for planting. The late arrival of seed consignments is due to many factors such some problems in

the seed producing countries such as unsuitable weather conditions leading to late harvest, inspection and grading, the availability of the sufficient vessels for shipment and in some cases the long shipping distances, or some delays in actual shipping. The late arrival of seed and the subsequent late and unsuitable planting have caused the following problems:

a) A remarkable decrease in the yield of potatoes, sometimes reaching 20 to 30% in Egypt, due to the high temperature prevailing during the proper planting dates.

b) The productivity of seed used for the second crop (fall crop) is significantly lower when saved from a late spring planting as compared with those taken from a more suitable early spring planting. This is due to the greater chance of virus vectors to spread during the late growing period beside other physiological factors.

c) The most serious problem resulting from the late arrival of seed and consequently delayed planting is the widespread and severe field infection of potato tuber moth Pathoremia opercullela. This insect causes very heavy losses in the field and during storage in all the countries of the Mideast.

   In Egypt we found that delaying the planting date of the spring causes more than 20% infection in the tubers with this insect, whereas the very early planting was completely free from such infection. Tubers infected with tuber moth are difficult to store, because they are more susceptible to Fusarium and the Soft rot bacteria.

In view of the above mentioned problems the following suggestions are presented for discussion:

1) Establishing a well-trained staff in seed potato production, certification and storage in every major potato production country. This can be accomplished by training appropriate technical personnel in developed countries or International Organizations such as CIP.

2) Introduction and evaluation of clones and varieties produced in regions with similar environmental conditions to the Middle East and North Africa.

3) Studying problems and potentials of each country for establishing its national program suited to its individual circumstances. Cooperation between the countries of the region as well as technical and personnel exchange are also important.

4) Multiplication of high quality imported seed locally, to satisfy the requirements, so that importation will be limited to remultiplication for one year. This is an urgent solution which would decrease the importation costs 75% annually if such a seed multiplication program is realized.

5) For a long term solution, each country within a regional program can participate in a cooperative effort where some countries exclusively produce the basic seed for further multiplication or production in other countries.

   Of course, this cannot be realized without practicing the above mentioned solutions. Furthermore, the developed countries are requested to offer technical experience and help in cooperation with CIP, A.C.A.D. (Arab Organization for the Agriculture Development) and other International Organizations.

Finally, I would like to express sincere thanks and appreciation to all who have contributed and prepared for this conference.

APPENDIX I

The acreage and production of some certified seed producing countries

	ACREAGE (1000 ha)				PRODUCTION (1000 metric tons)			
	1965	1970	1971	1972	1965	1970	1971	1972
S.America	977	1059	1062	1152	7010	9087	8632	7997
U.S.A.	741	772	738	673	14990	17896	17312	15849
Europe	8657	7354	7025	6823	138283	136286	120395	128153
U.S.S.R.	8638	8064	7894	8000	81628	96783	92655	77800

APPENDIX II

The total acreage and total production of potato in some Arabic countries

YEAR	AREA (100 ha)	PRODUCTION (100 metric tons)
1948-1952	65	130
1952-1965	96	192
1967	100	200
1968	115	230
1969	117	234
1970	129	258
1971	127	254
1972	133	266

(x) Iraq - Lebanon - Syria - Yemen
Algeria - Egypt - Libya - Morocco - Suden and Tunisia

(xx) imported seed 108000 tons.

INNOVATIVE RESEARCH IN SEED PRODUCTION APPLICABLE TO DEVELOPED COUNTRIES APICAL MERISTEM TECHNIQUES

N. S. Wright

The apical meristem technique has been used in Europe and North America during the past decade to cure completely infected varieties of potato and other vegetatively propagated crops. Actually, the meristem alone is seldom excised because the chances of growth in artificial medium are so small. When the meristem plus one to three leaf primordia are excised the survival rate is good and so are the chances of growth, providing a suitable medium has been selected.

Because of the practice of excising more than the meristem, a variety of names have been assigned to the same technique. Some of these are meristem culture, meristem-tip culture, culture of shoot apices, shoot tip culture, and axillary bud culture. In the treatment of potatoes, some workers find it beneficial to establish a rooted cutting in soil and to grow the cutting in a heat chamber in which the air temperature is approximately 35°C for about six weeks before attempting meristem culture. Whether the heat therapy increases the volume of virus-free tissue or merely makes the tissue more suitable for excision and culture is not known.

At the Research Station in Vancouver, Canada, the eradication of potato viruses X and S (PVX and PVS) from varieties of importance in Canada and U.S.A. was undertaken in 1967. The current collection includes 56 named varieties and 28 numbered seedlings in advanced stages of evaluation. The work is still in progress and approximately 20 accessions are added each year. Most are varieties or seedlings which are new to the collection but some are additional clones of varieties already represented.

Shoots are removed from heat-treated plants grown from rooted cuttings. Surface sterilizing has been found to be unnecessary. Axillary buds are excised under a dissecting microscope (magnification X25) with a fragment of razor blade held in

razor blade forceps. The meristematic dome and two or three leaf primordia are moved to a culture tube on the tip of a needle. A good medium for growth of potato is the one used by Murashige and Skoog (Physiologia Plantarum 15: 473-497. 1962). The excised buds are maintained at 23-25°C under continuous fluorescent light. When roots and stems are 2-3 cm long the plantlets are transferred to soil and covered with a beaker, or held under mist, for a week following transplanting.

Initial indexing for PVX is done when the plants are transferred from the culture tuber. A small leaflet from each is ground in a drop of water in a well on a porcelain spot plate and used to inoculate Gomphrena globosa. The grinding and inoculating is done with a sterilized, rounded glass rod. The plantlets which appear free of PVX are checked for PVS by tube precipitin serology as soon as sufficient leaf material is available, usually in 2 to 4 weeks. Plants which appear to be virus-free are re-indexed several times during the next 6 to 12 months. Varieties differ considerably in the ease with which they are rendered free of these viruses but to date all attempts to treat a variety have succeeded sooner or later.

The potato stem cuttings technique is utilized to transfer to the field sufficient plants to produce the required number of tubers in the first year. In subsequent years propagation by tubers is practiced.

PREPARATION* AND COMPOSITION OF MURASHIGE AND SKOOG'S (1962) MEDIUM (MS) AS USED IN THE PRESENT EXPERIMENTS

Stock Soln.	Constituents	Conc. in stock soln. gm/l	Volume of stock soln. in final medium ml/l	Final conc. in medium mg/l
A	$NH_4\ NO_3$	82.5	20	1650.0
B	KNO_3	95.0	20	1900.0
C	$H_3\ BO_3$	1.24	5	6.2
	KH_4PO_4	34.00		170.0
	KI	0.166		0.83
	$Na_2\ MoO_4\ 2H_2O$	0.05		0.25
	$CoCI_2\ 6H_2O$	0.005		0.025
D	$CaCl_2\ 2H_2O$	88.0	5	440.0
E	$MgSO_4\ 7H_2O$	74.0	5	370.0
	$MnSO_4\ H_2O$	3.45		22.3
	$ZnSO_4\ 7H_2O$	1.72		8.6
	$CuSO_4\ 5H_2O$	0.005		0.025
F**	Na_2 EDTA	7.45	5	37.35
	$FeSO_4\ 7H_2O$	5.57		27.85
G	Thiamine.HCI	0.02	5	0.1
	Nicotinic acid	0.1		0.5
	Pyridoxine HCI	0.1		0.5
	Glycine	0.4		2.0

Addendum: Sucrose 30 gm/l, myo-inositol 100 mg/l, Kinetin 0.04 mg/l (also if desired Indole 3-acetic acid 10 mg/l, Agar 10 gm/l).

* The stock solutions A-G were prepared and stored in a refrigerator and mixed just before preparing the final medium.

** The $FeSO_4$ $7H_2O$ is dissolved in about 200 ml double distilled water. The Na_2 EDTA is dissolved in about 200 ml double distilled water, heated and mixed (under continuous stirring) with the $FeSO_4$ $7H_2O$ solution. After cooling, the volume is adjusted to 1000 ml. Heating and stirring result in a more stable Fe-EDTA complex.

Add required volume of stock solutions to ca. 800 ml distilled water.

Add sucrose, myo-inositol, Kinetin (and I A A).

Adjust volume to 1000 ml. with distilled water.

Adjust pH to 5.75 with 2% NaOH.

Dispense medium into tubes.

Autoclave 10 minutes at 12 pounds pressure.

August 10, 1974

Virus-free Potatoes, C.D.A. Research Station
Vancouver, Canada

A 503-42	* Early Rose	G 6551-7y
A 6371-2	* Epicure	G 6920-3
* Abnaki	F 59075	* Gold Coin
Alamo	F 60075	* Green Mountain
Alaska 114	F 60087	Hudson
Alaska Russet	F 61013	* Huron
* Arran Consul	F 61019	* Katahdin
Arran Victory	F 61025	* Kennebec
* Avon	F 62012	* Keswick
Banana	F 63001	La Chipper
* Belleisle	F 64073	La Rouge
* Canus	F 66077	Lilly
* Cariboo	FS 6339	* Manota
* Cherokee	* Fundy	Menominee
* Chieftain	G 597-20	Monona
Chinook	G 678-3Ru	Nampa
* Columbia Russet	G 6546-6p	* Netted Gem
* Early Ohio	G 6549-7	(Russet Burbank)

N.D. 6634-2R
N.D. 7003-2
N.D. 7103-4
N.D. 7196-18
N.D. 7642-2 russ
N.D. 8200-4R
N.D. 8297-1
N.D. 8706-11 russ
Nooksack
Norchief
* Norchip
* Norgold Russet
* Norland
* Onaway
Ontario
Peconic
Pembina Chipper
* Pungo
* Raritan
* Red La Soda
* Red Pontiac
* Sable
* Sebago
* Superior
Targhee
* Warba
* Waseca
W.C. 230-14
White La Soda
* White Rose
* York

* Licenced for certification in Canada.

BREEDING FOR VIRUS RESISTANCE

P.R. Rowe

Well known genetic resistances exist for most viruses that infect potatoes. These includes resistance to PVX, PVA, PVS, PVY. Similar high levels of resistance have not been reported for PLRV and PSTV. Breeding programs have produced varieties with resistance to virus, but it is difficult to name any variety that is grown primarily for its virus resistance. Clearly this is because in North America and Europe virus diseases have been controlled through seed certification programs, thus largely doing away with the need for resistant varieties.

To date, this same reasoning has influenced the research program of CIP. Breeding for virus resistance has not been stressed because it appeared to be a duplication of seed production efforts. But does this hold for all countries? For all levels of potato production?

One can well argue that there are systems of agriculture and countries where a seed certification program is likely to be completely ineffective. For these situations, should CIP organize a major effort to incorporate high levels of virus resistance into genetic stocks? If so, what resistance factors are the most important?

The discussion on this subject should be directed towards the development of ways in which breeding research can compliment seed production programs.

THE POSSIBILITIES OF GROWING POTATOES FROM BOTANICAL SEED

P. R. Rowe

The primary advantage of a system of using seed is that it provides a means to start with healthy potato plants, virtually free of virus diseases.

A successful program would eliminate the need for a sophisticated certification program. Of considerable importance as well is that tubers that are now used for planting could be consumed.

The extensive segregation found in progenies from crosses of potato cultivars has made such a scheme difficult to conceive. However, recent research findings have provided at least a partial solution to this problem. Work conducted by Dr. S.J. Peloquin and co-workers has shown that tetraploid progeny produced from tetraploid-diploid or diploid-diploid crosses are both extremely uniform as well as vigorous and high yielding.

This is due to the fact that the diploid produces a high frequency of 2n gametes via first meiotic division restitution (FDR). The progeny are then individually highly heterozygous but the families are more uniform than usually observed.

To develop this method, the following procedure could be used:

- Identify diploid clones that combine good agronomic characteristics with production of 2n gametes by FDR.
- Identify good combinations, i.e., clones that produce agronomically acceptable, mainly tetraploid, progeny efficiently. These means that:

  1. they "nick" well
  2. produce 2n gametes in reasonably high numbers

If a female diploid parent with the required characters is not available, a male sterile tetraploid clone could be used as female in a 4X x 2X cross. Seed would be produced by planting

the parents in the field. For example, 3 rows of the female 4X parent to one of the male parent, and isolated from other potato pollen sources. Harvest only the fruit produced by the female parent. The use of two diploid clones would be advisable if:

1) 2n gametes are produced by FDR in both sexes,

2) the proportion of 4X progeny is high and

3) the 2X progeny is easily identified and discarded.

Such a scheme seems feasible and further breeding and selection could probably provided improved seed. However, there are other cultural problems that will have to be considered and studied if botanical seed is to be used on a full scale. The following are some factors to be considered:

1. Longer growing period. Plants from seed will need at least 30 days longer to mature. In areas with spring frosts and short growing seasons, young plants would have to be started under cover and transplanted to field after a frost-free date. Plants from seed have very little potential for recovery after frost.

2. Smaller yield per plant. This could be somewhat overcome by closer spacings.

3. Higher technological requirements. Anyone using a seed system would have to learn procedures for planting, maintaining, and transplanting somewhat delicate plants. This is not impossible but seedlings require careful care and costs are higher.

4. Increased labor inputs. This depends upon the system used:

   a) Direct seedling into field. This would use the least labor but would require a carefully prepared seedbed, and rather exact placement of seed in the soil.

   b) Transplant to field from beds. Requires a careful planting operation and an irrigation system (or timely rain) to get a high percentage of successs.

c) Transplanted to small containers that are then transplanted to the field. This involves an extra transplanting operation that requires space to hold plants while in containers (usually for 3-4 weeks). A simple type of container (i.e. Jiffy pot) is required.

5. Will require the development of a seed production and distribution system. Depending upon the genetic system used to produce the seed, farmers would have varying degrees of success in keeping seed produced on their plants. It is difficult to anticipate the cost of production of seed, but probably not high.

6. Almost no genetic integrity for a "variety". A commercial field would be a mixture of genotypes. This is not bad but the whole variety concept and tradition for the crop would have to be changed in most areas.

7. Less adaptation to environmental stress. Young plants from tubers have a reserve that tends to support them in times of frost, drought, insect attack, or other plagues. A plant from a seed has no such support and as a result will be reduced more severely by stress.

8. Less land suited for potatoes. The system could not be used with very heavy soil nor in extremely hot, dry areas.

A PROPOSAL FOR THE STUDY OF THE ECONOMIC ASPECTS OF SEED PRODUCTION

M. Twomey

INTRODUCTION

Increasing the production of certified seed is the foundation of the action program planned by the Outreach Program of CIP. Continued use of the same seed stock by farmers can lower yields, often considerably, because of infection with virus and other diseases. Seed multiplication program can be very instrumental in the rapid production of large quantities of new varieties which have desirable qualities such as greater resistance to diseases and higher yields. Finally, many countries have to import high quality seed, and this drain on scarce foreign exchange resources can presumably be avoided by the development of programs which increase small quantities of imported seed.

CIP has very little information on the economic aspects of seed production. Each of the above three considerations on the importance of seed production is ultimately founded on economic factors. The purpose of this proposed study is to obtain information on the economic aspects of seed production, thus making our Outreach activities more effective in countries around the world.

There are three basic questions to be considered:

1) Under what conditions is a seed certification program economically advisable?

2) In the production of certified seed, what is the optimal maximum level of virus and other infections that can be permitted?

3) What are the farmers' considerations with regard to sanitary quality of seed, seed size, and frequency of purchase?

The proposed study is not an agronomic investigation per se, although some field research may be deemed necessary. There is an immense amount of information available, some of it published, to which the relevant economic analysis can be applied. Obviously, the first part of the investigation will be a review of the literature, and a discussion with the participants in our Workshop on Seed Production Technology in October 1974, whose own seed production programs, and personal experience should provide other important information.

We shall discuss the first two questions under the heading Seed Production and the third question under the heading Seed Use.

SEED PRODUCTION

The basic data for this investigation will come from an analysis of on-going seed programs in selected developed and underdeveloped countries. Comparison of the different programs will provide a range of estimates of the costs of the different parts of a seed production program, and hence of the advantages involved in the different strategies adopted in the various countries.

1) Cost of seed program

Any given country can import and multiply high quality seed, or it may develop and produce its own high quality basic seed, to later increase through one or more multiplications. This part of the study will proceed as a straightforward enumeration of the various costs associated with these two phases, production of basic seed, and multiplication. Costs will be expressed in physical units of input (m^2 of greenhouse, man days of laborers, hectares of land, etc.), and in monetary units. It will then be converted to costs per unit of output, either in kilos of seed or hectare produced.

One important consideration is how are unit costs reduced when the scale of production is increased, under the assumption of the presence of economics of scale to basic seed and multiplication programs. Hopefully, a methodology will be worked out by which any country can determine what is its optimum number of multiplications. One might also compare how much costs increase with an increasing number of varieties. Finally, an important consideration is the foreign exchange cost of these programs, and alternative total costs can be estimated by using the actual exchange rate and a "shadow" exchange rate reflecting artificially induced scarcity

of exchange due to controls.

A study of the costs of a program of this type can at best be indicative, not definitive. One cannot measure the value of many other benefits to national governments of seed programs, such as the training and experience gained by technicians, greater flexibility of the national agricultural programs, and the desire to be economically self sufficient.

2) Increasing costs of raising the sanitary level of seed.

Using as a point of departure the information gathered in the above study, this most important factor will be studied. Increasing the cleanliness of seed will involve more visits by Inspectors and technicians, more rouging and hence less yield, and perhaps more laboratory tests. The rate of virus spread in seed is the factor which reduces the yielding ability of seed, and will have to be studied, although it can only be roughly estimated.

Costs need study, amongst other reasons, in order to provide guidelines for the pricing of seed. In countries with a well developed seed production and distribution program, it is possible to let the market determine the selling price of potato seed. However, this is clearly not feasible in many countries where Outreach will be working, and moreover, policy makers must have an idea of the trade-offs between increasing the quantity of lower priced seed as opposed to increasing its quality.

FARMERS' CONSIDERATIONS

Whereas the above study will be based on an analysis of data from existing programs, this part of the investigation is more specifically a technical analysis of agronomic factors. As already mentioned , a thorough review of the literature will provide much of the necessary information, or indicate where it can be found. Some investigations in the field may also be necessary.

There are three points of importance to the farmer which will be studied: optimal seed size, the economics of the frequency of purchasing seed, and the increase in yields with the use of clean seed.

1) The economics of seed size.

Seed is usually sold on a per unit weight basis; often with different prices for two or three average sizes of seed. A preliminary review of some publications indicates that the influences of seed size on yield has received much attention. The same is true of the influence of plant density and other agronomic factors on the production of tubers of the "right size for sale as seed. There is, however, disagreement on the advantages of using cut seed; one factor apparently overlooked is the increase in the costs of production caused by the additional work and materials needed to cut the seed.

2) Increasing yields through the use of cleaner seed.

The goal of a seed program is the production of clean seed whose use will increase farmer's yields. This increase in yield must be documented, it will vary by variety, presence of other pathogen, agronomic practices, and a host of ecological variables. With respect to one agronomic practice, fertilization, it would be best to speak of increasing the <u>responsivity</u> of cleaner seed to fertilization. One can look at how yields increase at maximum rates of fertilization, at the economic maximum rate, at "average" and "low" doses of fertilizers, and at zero rates. The methodology of analysis is well known in the agricultural economics literature. It has been argued, and should be investigated, that the poorer farmers who do not use fertilizers do not have the incentive to use expensive clean seed, because the increase in their plots do not justify the investment in new seed. This of course is one of the reasons for other Centers' concentrating on introducing technology "packages" of seed, fertilizers, irrigation, etc. in their Outreach programs.

3) The economics of the frequency of purchase of seed.

It appears that many farmers throughout the world do not buy new potato seed year after year, and the economic rationality of this practice, can also be studied, by comparing total net income over a three to five year period of different practices. The rate of spread of viruses, and its variability, is the single most important variable here, because otherwise the use of seed from last year's production obviously represents a saving in the costs of production to the farmer, for whom new seed often represents from thirty to forty percent of total costs.

A point relating the frequency of purchase of seed and size is the practice of selling large tubers, for table stock, and keeping the smaller ones for seed. It is clear that these smaller tubers would represent a lesser income if they had been sold on the market for consumption. However, this must be contrasted with the reduced potential yields of these tubers when used as seed, because of genetic factors of selection, and increased infestation.

These questions with respect to the farmers' considerations on purchased seed must obviously be judged with some idea of the frequency of the practices in a given country or area. For this purpose some surveys of production practices will be advisable.